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INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

13th SESSION (PARIS, 1937).

QUESTION V.

Recent improvements in steam locomotives

of the usual type and tests of new designs (high-pressure reciprocating locomotives and turbine locomotives) as regards construction, quality of materials used, efficiency, working conditions, maintenance and financial results.

Testing locomotives

at locomotive experimental stations, and in service with dynamometer cars and brake locomotives.

REPORT

(Great Britain, Dominions and Colonies, America, China and Japan),

by Sir H. Nigel GRESLEY, C.B.E., D. Sc.,
Chief Mechanical Engineer, London and North Eastern Railway.

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Buenos Ayres and Pacific Railway.
Buenos Ayres Western Railway.
Central Argentine Railway.

United States of America :

Baltimore and Ohio Railroad.
Delaware and Hudson Company.
Pennsylvania Railroad.
Reading Company.

Great Britain and Ireland :

Great Western Railway.
London Midland and Scottish Railway.
London and North Eastern Railway.
Southern Railway.
Great Southern Railway (Ireland).

Africa :

Nigerian Railway.
South African Railways and Harbours.
Sudan Railways.

India :

Great Indian Peninsula Railway.

Japan :

Japanese Government Railways.

The Reporter desires to record that, whilst much valuable information has been supplied by the four American Railways holding membership of the International Railway Congress Association, the various practices in use on these Railways may not necessarily be fully representative of modern American practice as a whole.

* * *

PART ONE.

Improvements in steam locomotives of the usual types since 1930.

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CHAPTER ONE.

Increased boiler pressure since 1930.

a) The increased pressure and the amount by which it has been raised.

Seven Railway Companies report increases in boiler pressure on engines of the usual types, in accordance with the table given below :

Administrations.	*Buenos Ayres Great Southern.*		*Buenos Ayres and Pacific.*	*Delaware and Hudson.*	*London Midland and Scottish.*	*London and North Eastern.*	*Nigerian.*	*Japanese Government.*	
	Lb. sq. inch.								
Pressure prior to 1930.	150	160	175	...	...	220	200	185 *(13 kgr./cm²)*	
The increased pressure.	175	200	200 (*)	325	250	250	225	*Normal.* lb./sq. in. 199.5 *(14 kgr./cm²)*	*Maximum.* lb./sq. in. 214 *(15 kgr./cm²)*
The amount of increase.	25	40	25	...	...	30	25	14.2 *(1 kgr./cm²)*	28.4 *(2 kgr./cm²)*
For diagram of engine with raised pressure see Appendix No. :	...		A/1	L/11 (Chapter 12).	L/12 (Chapter 12).	L/23 (Chapter 12).	...	A/3, A/4. and L/28 (Chapter 12).	

b) Particulars of special provisions made in design and construction in view of the higher working pressure.

All the boilers follow orthodox design for fire tube boilers. The London and North Eastern Railway (L. N. E.) locomotives have thickened barrel plates, and the pitch and diameter of the copper stays have been adjusted. The boilers of the Buenos Ayres Great Southern were originally designed for the higher pressure, but had worked at the lower pressure.

(*) Replace boiler for 4-6-2 type engines.

c) Special metals used for plates and firebox stays.

The Delaware and Hudson, and the London, Midland and Scottish Companies employ nickel steel for the boiler shell and wrapper plates; the other Railways have made no change in the material used for the plates. Firebox throat plate stays on the L. M. S. are made of « Monel » metal, and the Delaware and Hudson Company employ « Ewald » iron for flexible stays and « Burdon » iron for rigid stays. See Appendix A/2 for particulars of L. M. S. metals.

d) **The influence of raising the pressure, on :**

I) *Cost of maintenance and periodical examination of the boiler.*

The boilers have not been in service long enough for any comparison of maintenance costs to be made. The L. N. E. and Japanese Government Railways report no increased frequency in periodical boiler examination.

II) *Availability of the engine.*

The Buenos Ayres Great Southern reports no change in availability.

The L. M. S. Company reports a 75 % availability with one class of engine having the new 250 lb./sq. in. boiler. The L. N. E. R. reports no reduction.

III) *Mileage between general repairs, boiler renewal and re-tubing.*

The Buenos Ayres Great Southern and the Japanese Government Railways report no difference.

The L. N. E. R. do not anticipate any decrease, but like the other railways, it is as yet too early to make a definite statement.

* * *

CHAPTER TWO.

Improvements in water circulation since 1930.

1. Steps taken to improve water circulation.

Arch tubes have been fitted to 23 engines of the Reading Company and, for trial, on two engines of the Buenos Ayres and Pacific Company. The Japanese Government Railways also report the fitting of arch tubes.

Thermic syphons have been largely adopted by the Reading Company, and 55 engines have been fitted. The Buenos Ayres and Pacific and the Delaware and Hudson Companies have each one engine fitted for trial.

The remaining Administrations do not report the adoption or trial of any special fittings to improve water circulation.

a) **Results obtained.**

The Reading Company reports increased safety and economy with arch tubes and thermic syphons, whilst the Japanese Government Railways have improved the circulation, extended the life of brick arches and decreased the coal consumption of engines by the fitting of arch tubes.

b) **Comparative evaporation.**

The Reading Company, with syphons, have realised a 13 % increased evaporation.

The results obtained by the Japanese Government Railways from tests with arch tubes shew an increased evaporation of 6.8 % over similar engines not fitted.

c) **Comparative maintenance costs.**

The only Administration to reply to this question is the Japanese Government Railways, which claim to have reduced the maintenance costs by the fitting of arch tubes, mainly on account of the extended life of the brick arch.

d) **Defects arising from any improvement effected, and steps taken to remedy them.**

No Railway Company reports any defects arising from the fitting of thermic syphons or arch tubes.

2. Particulars of chemical treatment of boiler water.

(See also brief summary of individual replies at the end of this Chapter.)

Prior to summarising this part of Chapter Two, the Reporter desires to record that the Japanese Government Railways have submitted a very complete statement on the process adopted by them, but that space does not permit

of more than the brief summary made being included in this report.

a) **Types of treatment.**

With the exception of the Pennsylvania Railroad and the Great Indian Peninsula Railway, some chemical treatment of boiler feed water has, in varying degree, been applied.

The majority of Railways have adopted lime and/or soda-ash treatment by external plants or treatment of tender water direct, using soda-ash or other reagent. Plant treatment is supplemented in many cases by sodium aluminate, or other coagulant.

The tendency of the Argentine Railways is to adopt the Base-Exchange process. The Buenos Ayres and Pacific Railway has 25 softeners of this type and three soda-ash plants, whilst the Central Argentine has one plant of each kind. The Buenos Ayres Great Southern and the Buenos Ayres Western Railways state that they have recently decided upon the base-exchange process employing « Zeolite », and a number of plants are being installed. No further information, however, has been supplied by these two Administrations.

The Delaware and Hudson Railroad have apparently so many different kinds of water to contend with, that in each individual instance the water is specially treated.

The Japanese Government Railways have, after much research, finally adopted an internal treatment, using potassium bi-chromate and soda-ash, and applied it to 70 % of their engine stock.

b) **Residual hardness and alkalinity.**

The degree of hardness left in the treated waters of the Administrations using lime and/or soda-ash processes varies between 1.2° and 3.5°, the residual alkalinity range being 1 to 8 grains per gallon, with the exception of the London, Midland and Scottish Railway, the Great Southern Railway of Ireland and the Central Argentine Railway. The L. M. S. do not at present soften below 7° leaving no residual soda alkalinity. The Irish Railway and the Argentine Railway soften down to 5°, the latter leaving the water alkaline to the extent of 5 grains per gallon.

While some Railways make no attempt at complete softening, the Buenos Ayres and Pacific and Central Argentine Railways, with their base-exchange process, obtain waters of zero hardness with high soda alkalinities, e.g. 30 grains per gallon on the Central Argentine Railway.

c) **Effects of softened waters.**

I) *Priming.*

With the lime and/or soda-ash treatments, 50 % of the Administrations employing them report priming, but in no case has the priming been reported as severe. The use of blow-down or more frequent water changes has prevented priming reaching a degree of severity sufficient to cause lubrication difficulties at the front end, loss of superheat or erosion.

The individual treatments given by the Delaware and Hudson Railroad are stated to be free from priming, and the Japanese Railways report very slight priming with their boiler compound treatment. No priming is reported where the base-exchange process, coupled with intermittent blow-down, is employed.

II) and III) *Corrosion and pitting.*

No Railway using lime and/or soda-ash treatments reports any increase in corrosion; the Nigerian Railway claims to have prevented corrosion by the use of soda-ash only.

Pitting of tubes on the L. M. S. R. has increased, but it is hoped by softening the water eventually to 1° and leaving the water 3° to 4° alkaline, that this will be overcome.

On the South African Railways the pitting of tubes has been reduced by the use of water softened by lime-soda.

The base-exchange process and subsequent conditioning has resulted in the corrosion of copper, but steel is unaffected.

The special treatments of the Delaware and Hudson Company have not resulted in any corrosion or pitting. The pot : bi-chr. treatment of the Japanese Government Railways has an anti-corrosive effect and pitting has been practically eliminated.

IV) *Attack on fusible plugs.*

The L. M. S. R. reports that their lime-soda softened waters dissolve the lead filling, but that thin copper, electrically deposited on the lead, overcomes this. The L. N. E. R. have had a few cases where lime-soda softened alkaline waters, depositing no protective scale, have caused some damage to the lead.

The South African Railways (lime-soda process) report isolated cases of damage to the lead.

Railways using other softening processes do not report any trouble in this respect.

Improved evaporation.

The Baltimore and Ohio Railroad estimate a 7 % increased evaporation from lime-soda softening. Other reports of the lime and/or soda treatments are from the L. N. E. R., the Nigerian and the South African Railways, which report free steaming and some fuel economy from cleaner boilers. The Japanese Government Railways report an increased evaporation with a decrease in fuel consumption, but point out that an exact relationship is not traceable between water treatment and evaporation.

The base-exchange process is stated by the Buenos Ayres and Pacific Railway to have realised a 10 % economy over the soda process.

3. Blow-down.

See also brief summary of individual replies)

a) **Type.**

Continuous automatic blow-down is being fitted to all engines of the L.M.S.R., it is being tried experimentally on the L. N. E. R. and is also in use experimentally on the G. W. R. The Japanese Government Railways are extending gradually the use of continuous blow-down, and approximately five per cent of the engines are now fitted.

Intermittent hand-controlled blow-down is, in varying degree, used by the G. W. R. and by the other Railways replying to this question, with the exception of the Delaware and Hudson, Southern, Great Southern of Ireland and Nigerian Railways, none of which blow-down when running. The Baltimore and Ohio report that experiments are in hand with an automatic electric device which operates when the foam reaches a predetermined level.

b) **Rate of blow-down.**

Rates of continuous blow-down are as follows :

L. M. S. R.	1 to 2.7 gallons per minute.
G. W. R.	1 gallon per minute.
Japanese Government .	1 litre (1 3/4 pints) per minute.

The rate of intermittent blow-down is too varied to draw any conclusions.

c) **Position in boiler, from which blow-down water in taken.**

Six Railways take the blow-down water from immediately above the foundation ring and three from points 2″ above the level of the firebox crown, two of which are from the firebox end and the other from a point mid-way along the barrel.

d) **Description of blown-down valve.**

Since nearly all the blow-down valves are of different types, drawings of typical examples have been included in the Appendices to this Chapter, and brief descriptions appear in the detailed summary for each Railway employing them.

e) **Increase in periods between wash-outs, due to fitting blow-down.**

Generally speaking, periods between wash-outs have been increased, to as much as 300 % on some Railways.

f) **Effect on fuel and water consumption.**

It is clear that a heat loss must occur if hot water from the boiler is blown down to the track whilst running, but in most cases this loss is more than compensated by the economy which accrues from an extended period between washing out and lighting up, and the greater efficiency of clean boilers.

* * *

SUMMARY OF INDIVIDUAL REPLIES (CHAPTER 2, QUESTION 2).

2. **For locomotive boilers in general, has the use of chemically softened water been adopted, and if so:** a) **Give particulars of the water softening treatment employed.**

Buenos Ayres Great Southern. — Base exchange system employing « Zeolite » has recently been decided upon, and a number of plants are being installed, but no further information is yet available.

Buenos Ayres and Pacific. — Two systems adopted: (I) Three caustic-soda, soda-ash plants. (II) Twenty-five base-exchange plants.

Buenos Ayres Western. — Base-exchange system employing « Zeolite » has recently been decided upon, and a number of plants are being installed, but no further information is yet available.

Central Argentine. — Not generally adopted. Two plants only installed: (I) Lime-soda plant installed at Cordoba, 1931. (II) Base-exchange plant installed at Santa Fe, 1934.

Baltimore and Ohio R. R. — Three systems adopted: (I) Lime-soda plants. (II) At places where small demand for water exists, soda-ash proportioning apparatus. (III) Soda-ash applied direct to locomotive tender.

Delaware and Hudson Co. — Chemical treatment specially prepared to suit individual waters in certain restricted zones. Systematic check of treated water taken to determine variation.

Reading Co. — Soda-ash and sodium aluminate pumped into the roadside tanks automatically. Electric control.

Great Western. — Lime soda-ash process.

London Midland and Scottish. — Approximately 40 % of the locomotive feed water. Hydrated lime and soda-ash. Aluminium sulphate (sodium aluminate in the case of magnesium waters) used to assist coagulation. Final clarification generally by sand filters; in some cases by wood wool filters.

London and North Eastern. — Not yet universal, but general on sections of main line. Tendency is to extend. Treatment in external plants, lime; lime and soda; and in the latest plants, lime, soda and sodium aluminate.

Southern (Gt. Bn.). — Chemical water-softening at important sheds. Lime, soda and sodium aluminate.

Great Southern of Ireland. — Lime, soda. Hardness 5° Clark.

Nigerian. — Soda-ash placed in tender.

South African. — At selected locations to suit traffic and other conditions.

Lime-soda process.

Sudan. — Paterson's lime and soda plant.

Japanese Government. — No softening plants. Internal treatment applied to 70 % of engines.

Potassium bi-chromate and soda-ash introduced after blowing down when re-filling.

b) **What final degree of hardness is left in the treated water, and to what limit is the water left alkaline ?**

Buenos Ayres and Pacific. — (I) Alkalinity adjusted to pH. value 9.8 to 10.0 (soda-ash process). (II) Hardness less than 0.035° Clark (Base-exchange process).

Central Argentine. — (I) Hardness approximately 5°. Total alkalinity approximately 5 grains per gallon. (II) Hardness 0.1°. Alkalinity 30 grains per gallon.

Baltimore and Ohio R. R. — (I) Average hardness 1.5 to 2 grains per U. S. gallon. Sodium alkalinity 1 to 5 grains per U. S. gallon. (II) Only permanent hardness removed (temporary hardness therefore varies). Alkalinity 1 to 5 grains per U. S. gallon.

Delaware and Hudson. — Hardness 1.4° to 5.6° per U. S. gallon.

Reading Co. — Total alkalinity 1 grain per U. S. gallon above total (residual) hardness.

Great Western. — Hardness approximately 3° Clark. Alkalinity expressed as calcium carbonate, 4 grains per gallon.

London Midland and Scottish. — Hardness 7° to 8°. Residual soda alkalinity; nil.

London and North Eastern. — Hardness 1.2°. Total alkalinity varies from 2.5 (London Area) to 8 (Doncaster Area) grains per gallon.

Southern. — Hardness 2° to 3°. Total alkalinity 4 to 5 grains per gallon.

Great Southern of Ireland. — Hardness 5° Clark.

Nigerian. — Alkalinity to a pH. value of 8.

South African. — Hardness 3.5°. Alkalinity, 4.5 grains per gallon.

Sudan. — Hardness 3°. Alkalinity approximately 6 grains per gallon.

Japanese Government. — Aim at: hardness, less than 1°. Alkalinity, less than 10 grains per gallon.

c) **Has the use of chemically softened water produced any of the following undesirable effects, and if so, what steps have been taken to meet the situation ?**

(I) **Priming, resulting in lubrication difficulties in the steam chest and cylinders, and excessive wear of pistons and valves, reduction of superheat and erosion of superheater elements.** (II) **Corrosion of plates and stays.** (III) **Pitting of tubes.** (IV) **Attack on fusible plugs.**

Buenos Ayres and Pacific. — (I) No. (II) Steel not affected. Copper stays corroded (base-exchange process). (III) Steel tubes not affected.

Central Argentine. — Priming experienced with lime-soda treatment, though not sufficiently serious to cause difficulties. Base-exchange treatment has not caused any priming with clean boiler. (II) Base-exchange treatment has caused corrosion of copper and copper-bearing alloys. With the lime-soda treatment hard silica scale is formed. (III) Pitting of steel tubes to any extent is not noticeable with either treatment. (IV) No adverse reports received.

Baltimore and Ohio R. R. — (I) Priming experienced, but overcome by blow-down. (II), (III) and (IV) No.

Delaware and Hudson. — (I to IV) No.

Reading Co. — (I to IV) No.

Great Western. — (I) Priming experienced on boilers containing scale, but results obtained from experiments with blow-down very promising. (II) No increased corrosion. (III) No increased pitting. (IV) No increased attack on fusible plugs.

London Midland and Scottish. — (I) Priming when hardness below 7°, increasing as hardness decreases. Priming destroys superheat and causes damage to element joints. Lubrication difficulties experienced. Defects overcome by not softening below 7°, and by employing continuous blow-down. (II) No unusual corrosion. (III) Increase in pitting of steel tubes observed. To be overcome eventually by using softened water (1° hardness) containing 3 to 4 grains per gallon of caustic soda and soda-ash. (IV) Lead in fusible plugs dissolved by softened water. Thin copper film electrically deposited on lead has overcome this.

London and North Eastern. — (I) Priming increased in Doncaster Area and decreased in London Area. Period between water change at Doncaster reduced to meet situation but as less scale is now being produced, increased w. o. has not been necessary. No lubrication difficulties, loss of superheat or erosion encountered. (II) No increased corrosion. (III) No increased pitting. (IV) Alkaline waters, which do not deposit a protective scale, are apt to cause damage to lead filling.

Southern. — (I) Slight priming experienced, but has had no detrimental effect on cylinder and steam chest wear, loss of superheat or erosion. (II) No undue corrosion. (III) No undue pitting. (IV) No abnormal attack on fusible plugs.

Great Southern of Ireland. — I to IV. No.

Nigerian. — (I) No. (II) and (III) Soda-ash treatment claimed to have prevented corrosion of plates, stays and tubes.

South African. — (I) Priming very slightly aggravated, but without serious consequences. (II) No. (III) Pitting not entirely eliminated, but tubes now last four times as long. (IV) Isolated cases only.

Sudan. — No undesirable effects from Paterson lime-soda plant, but attacks on fusible plugs and priming have occurred. with five other plants installed prior to 1930.

Japanese Government. — (I) Priming very slight, no detrimental effect on cylinder and steam chest lubrication, or on wear of pistons and valves. Loss of superheat and erosion negligible. (II) Potassium bi-chromate and soda-ash treatment has an anti-corrosive effect on plates and stays. Recent research has shewn soda-ash alone may produce cracking of plates, hence the use of potassium bi-chromate to overcome this. (IV) Pitting practically eliminated. Durability of boiler tubes doubled. (IV) So slight, may be disregarded.

d) **What improved evaporation, if any, has been realised ?**

Buenos Ayres & Pacific. — The base-exchange process and conditioning has resulted in at least 10 % fuel economy over water treated by soda process only. In certain cases w. o. periods of two to three days have been extended to a water change once monthly.

Central Argentine. — Figures not available, but improved evaporation is realised.

Baltimore and Ohio. — Figures not available, but estimated improvement 7 % increased evaporation.

London & North Eastern. — Cleaner boilers and freer steaming of engines reported generally.

Southern (Gt. Bn). — None recorded.

Nigerian. — Increased evaporation owing to greater freedom from scale.

South African. — With cleaner boilers, only occasional blowing down necessary. Some fuel saving realised.

Japanese Government. — Improved evaporation realised, fuel consumption decreased. Exact relationship not traceable between water treatment and evaporation.

3. **Has the practice of blowing down a certain proportion of water from the boiler when running in order to decrease the concentration owing to the use of softened water been adopted ?**

Central Argentine. — Blow-down carried out at terminal points and sheds intermittently, also during trip where necessary.

Delaware & Hudson. — Blowing down performed twice weekly at running shed only.

London Midland & Scottish. — Blow-down being adopted on all engines.

London & North Eastern. — Experimental.

Southern (Gt. Bn). — Blow-down performed at running sheds only.

Great Southern (Ireland). — No blowing down of boiler water.

Nigerian. — Blow-down performed at running sheds only.

South African. — Not generally adopted. Only in bad water districts, occasionally.

Japanese Government. — Adopted gradually since 1932, about 5 % of engine stock now fitted.

If blowing down adopted, please state:

a) **Whether continuous (automatic or hand-controlled) or intermittent.**

Buenos Ayres & Pacific. — Intermittent, hand-controlled.

Central Argentine. — Intermittent, hand-controlled.

Baltimore and Ohio. — In general hand-controlled, but one engine fitted with an automatic electric device which operates when foam reaches a predetermined height above crown plate.

Reading Co. — Intermittent, hand-controlled.

Great Western (Gt. Bn). — Continuous blow-down, both automatic and hand-controlled.

London Midland & Scottish. — Continuous, automatic.

London & North Eastern. — Continuous (automatic) when regulator open. Means provided for rapid blow-down at will.

Southern (Gt. Bn). — Blow-off cocks only.

South African. — Intermittent, hand-controlled.

Japanese Government. — Continuous, automatic.

b) **Rate of blow-down if continuous, or when used if intermittent.**

Buenos Ayres & Pacific. — Dependent on condition of water and service.

Central Argentine. — Dependent on condition of water. Cock is opened every 50 to 70 kilometres, 4 to 5 times. It is open from 5 to 10 seconds with time interval of 15 seconds.

Baltimore and Ohio. — Dependent on concentration of soluble salts (maximum capacity of blow down valve 110 U. S. gallons per minute at 200 lb./sq. in.).

Reading Co. — Three blows of 20 secs. each intermittently.

Great Western (Gt. Bn). — One gallon per minute.

London Midland & Scottish. —From 1 to 2.7 gallons per minute according to class of engine.

London & North Eastern. — Rate not yet settled.

Southern (Gt. Bn). — Used once daily, when engine low in steam, and has stood. Valve is opened for a few seconds only, with a short interval between.

Japanese Government. — Rate can be varied to suit density of water. Discretion exercised to avoid unnecessary loss of heat by excessive exhaust of water. Average figure, 1 litre per minute.

c) **Give position in boiler, from which blow-down water is taken.**

Buenos Ayres & Pacific. — From two points in front of firebox immediately above foundation ring.

Central Argentine. — From front of firebox above foundation ring on centre line of boiler.

Baltimore and Ohio. — From lowest point in back water leg.

Reading Co. — From bottom of throat plate.

Great Western (Gt. Bn). — From a point about 2″ below normal water level above firebox crown.

London Midland & Scottish. — From a point 2″ above firebox crown close to back plate. (See diagram, appendix B/1.)

London & North Eastern. — From a point mid-way along the barrel, approximately 2″ above firebox crown plate level.

Southern (Gt. Bn). — From bottom of firebox.

South African. — From foundation ring and also from a scum cock, with intake just below water level on back of boiler.

d) **Give brief description of the blow-down valve and attach a working drawing.**

Buenos Ayres & Pacific. — Bronze vertical guillotine valve operated by stainless steel spindle. The valve is steam balanced

and is fitted with a strainer. (See Appendix B/2.)

Baltimore and Ohio. — Butterfly type blow-off cock with perforated pipe in water space and muffler at end of discharge. Discharge to track.

Reading Co. — « Wilson » type N. C. A. lever-operated cone valve with strainer in water space.

Great Western (Gt. Bn). — *Automatic continuous type :* Piston-controlled cone valve operated by steam from steam chest. Discharge taken through cooling coil in tank to track. On shutting regulator, valve closes automatically (see Appendix B/3).

Hand-controlled continuous type : Operates independent of whether engine is running or stationary. Concentrate taken direct from boiler by screw valve and passed through strainer and cooling coil in tank to track. Means provided for cleaning sieve.

London Midland & Scottish. — Operated by steam from steam chest. Blow-down water taken through cooling coil in tank and then to ballast (tender engines), and to ash-pan of tank engines. See Appendix B/1.

London & North Eastern. — Valve of L. M. S. pattern, but embodying in the stop cock a means for rapid blow-down at will. Discharge to ballast.

Southern (Gt. Bn). — Plain screw-down seating valve made in « Stabrite » steel.

South African. — « Everlasting » horizontal Guillotine type standard (see Appendix B/4).

e) **If, as a result of fitting blow-down, periods between washing-outs have been increased, and by what percentage.**

Buenos Ayres & Pacific. — Periods between wash-outs considerably increased, but due more to treated water than to blow-down.

Central Argentine. — Blow-down valves have always been a standard fitting. Comparisons not possible.

Baltimore and Ohio. — Periods between wash-outs increased 300 % by use of softened water and blow-down. Present standard period between wash-outs 30 days.

Reading Co. — 100 % increase in time between wash-outs in bad water districts.

Great Western (Gt. Bn). — Still experimental. Weekly boiler washing extended to two-weekly and monthly periods at a few depots.

London Midland & Scottish. — 100 % increase in mileage between wash-outs (express passenger from 2 500 to 5 000 miles).

London & North Eastern. — Experimental as yet.

Southern (Gt. Bn). — Increased a matter of a few days at present.

South African. — Washing out is performed to a fixed programme, regardless of state of water.

Japanese Government. — Periods between water change extended approximately 300 % on mileage basis.

f) **Effect on the fuel and water consumption.**

Buenos Ayres & Pacific. — Heat loss balanced by greater efficiency of clean boilers.

Central Argentine. — See reply to (*e*).

Baltimore and Ohio. — Blow-down has caused increase in coal and water consumption, but saving in fuel due to chemically treated water and blow-down far exceed pecuniary value of additional coal and water used.

Great Western (Gt. Bn). — No apparent effect at present.

London Midland & Scottish. — Water consumption increased 7 %. — Coal consumption increased 2 1/2 %.

South African. — Increased.

Japanese Government. — Effect on fuel consumption : Loss of heat averages about 0.36 % which is more than balanced by reduced coal consumption realised by increased periods between water changes, and consequent lighting up of boilers.

Effect on water consumption : The amount of water blown down when running is more than balanced by the amount saved in less number of water changes per period.

CHAPTER THREE.

Improvements in combustion since 1930.

1. Steps taken to improve combustion.

a) **Facilitating air entry into the grate.**

Whilst the general tendency has been to increase the area of air entry to the grate, the Baltimore and Ohio have reduced theirs.

Ash pans with three dampers are being fitted by the L. M. S., giving damper area of 30 % grate area, whilst the G. I. P. with a damper area of 11.8 % are able to burn 100 lb. coal per sq. ft. of grate area per hour with their special « Finger Rocking » grate. The Japanese Government Railways have 12 % to 15 % damper area inclusive of the area of the air holes placed in the upper part of the ash pan, at each side.

The Buenos Ayres Great Southern and the Buenos Ayres Western Railways have substituted side dampers for end dampers.

b) **Providing supplementary air above the fire.**

Three Railways only report having made special provision for supplementary air above the fire. The Baltimore and Ohio has fitted small air tubes in the sides of the firebox on a number of engines. The Nigerian Railway employs two methods, I) 2″ diameter holes drilled in the inner plate of the firehole door, and II) 3″ and 4″ diameter tubes inserted in the throat plate under the arch. In the second case the air space has been reduced from 42 % to 17 % of the grate area. On the Japanese Government Railways compressed air is introduced automatically after firing up through a nozzle situated in the top half of the firehole. Preheated air also enters the firebox through the lower half of the firehole door and through the side plates of the firebox.

c) **Relationship of air space through the grate to grate area.**

The general tendency is to increase the air space through the grate; the most outstanding example being the « Gaul Fin » grate of the Delaware and Hudson Railroad, which has a 60 % air space, as compared with 35 % to 50 % in grates of the orthodox types. The L. N. E. R. have adopted 56 % on the latest engines built, as compared with 30 % in previous designs. The L. M. S. Company has found 40 % satisfactory, but is experimenting with an air space of 50 %.

Other grates which have been adopted are the « Shaker » grate on the Buenos Ayres and Pacific, and the « Finger Rocking » and « Round Table » types on the Great Indian Peninsula Railway.

The South African Railways have adopted larger grates with 7/8″ and 1″ perforations, which, they claim, enable lighter fires to be carried.

d) **Combustion chambers.**

Seven Railways have experience with combustion chambers, one of which, the South African Railways, has discarded their use in recent designs. Orthodox lines are followed generally for the combustion chambers of fire tube boilers. The ratio of firebox volume to grate area in the case of combustion chamber fitted passenger engines is as six or seven to one. The length of the combustion chamber on the L. M. S. « Princess Royal » boiler is 3′ 6 1/4″ and that on the L. N. E. R. A.4 class *Pacific* engines, 4′ 2 1/2″. Appendix C/1 (Japanese Government Railways) illustrates the typical combustion chambers.

e) **Smokebox conditions.**

Smokebox conditions have been improved by the fitting of combustion chambers on the Japanese Government Railways. Percentage figures of improved gas analyses and temperature fi-

gures are given in detail in Appendix C/2 to this Chapter.

No other Administration has reported under this heading.

2. **Smoke consuming apparatus.**

Only the Baltimore and Ohio Railroad reports the adoption of a special device. Steam jets are introduced through the small air tubes in the firebox sides (mentioned in Question 1 *(b)* of this Chapter) of certain engines in areas where smoke abatement laws are in force. No fuel economy is claimed with this device.

The L. M. S. does not consider such apparatus necessary provided that in the design of the boiler, proper values are given to the following : firebox volume, alignment of brick arch and smoke deflector, percentage ratio through the flue tubes to grate area, length of tube to bore, and smoke box, blast pipe and chimney arrangement.

3 and 4. **New apparatus for cleaning smoke tubes, and if any deterioration of tube plates from the use of tube cleaners of the steam jet type.**

« Clyde » and « Parry » steam jet blowers are in use on the Buenos Ayres and Pacific and Great Indian Peninsula Railway (G. I. P.) Railways, the former Administration also employing a « Parry » blower modified to use sand. Grooved crown plates and general abrasion of tubes and tube plates have been observed by the Buenos Ayres and Pacific Company as a result of using tube cleaners of the steam jet type. The G. I. P., however, reports no such deterioration.

« Diamond » steam jet blowers are also used by the G. I. P. and no deterioration is reported. The Sudan Railways, on the other hand, report deterioration with the « Diamond » soot blower, although as a tube cleaner it is efficient.

Other new types of steam jet blowers are the « Ramoneur », used on the Nigerian Railway without detrimental results, and one, not named, which is on trial on 23 engines of the Baltimore and Ohio. This type is mounted on the firebox side, 2′ 6″ from the tube plate. No deterioration has taken place in the firebox.

The L. M. S. reports the use of sand guns operated by a steam jet on a number of engines. The cleaning of tubes is eliminated and no deterioration has been observed. Steam operated sand guns are also in use on the oil-fired locomotives of the Buenos Ayres Great Southern Railway. The apparatus is by no means new, having been in general service for approximately ten years, but no deterioration has taken place in the firebox from its use.

The Central Argentine, South African and Southern Railways have no new types of steam jet cleaners, but the former two Administrations report no deterioration, whilst the Southern Railway's experience is that erosion of tubes and tube plates takes place with the old types.

* * *

CHAPTER FOUR.

Higher superheat temperature of the steam since 1930.

1. Production of superheated steam.

a) Steps taken to improve superheating.

Various steps have been taken by the different Administrations to improve superheating. One experiment common to three Railways is the adoption, for trial, of trifurcated « Sinuflo » elements. The Central Argentine and L. M. S. Railways report a definite increase in the temperature of superheated steam realised, but the Nigerian Railway states

that the trial is as yet insufficiently advanced to report.

The Delaware and Hudson, and the L. N. E. Railways are conducting similar experiments in an extension of the length of the elements. The former Administration, in their 500-lb./sq. in. boiler with water tube firebox, employ elements projecting into the firebox, the first two rows 6″, the remainder 18″. They have realised an increase in superheated steam temperature of 80° F. The L. N. E. R. have brought the elements to within 9″ of the firebox tube plate on one of the A.4 type streamlined *Pacific* engines with fire tube boiler, an increase of 10″, but test data are not yet available.

b) **Effect of improvements in steam circuit on superheat temperature.**

The Central Argentine, Baltimore and Ohio and L. N. E. Compagnies all report higher temperatures of superheated steam obtained with engines on which the steam circuit has been improved. The detailed improvements made by each of these Railways are set out in Chapter Nine.

c) **Maximum temperature of superheated steam considered desirable and pressure used in conjunction with it.**

The following table gives the opinions expressed by the various Administrations which have replied to this question :

Administration.	*Buenos Ayres and Pacific.*	*Central Argentine.*	*Baltimore and Ohio.*	*Delaware and Hudson.*	*Reading.*	*London Midland and Scottish.*	*London and North Eastern.*	*Nigerian.*	*South African.*	*Great Indian Peninsula.*	*Japanese Government.*
Temperature °F.	630	643	750	850	700	700	750	650	750	720	752
Pressure, lb./sq. in.	200	225	350	300	250	250	250	200	200	180	284

2. Packing for valve spindles and piston rods.

(See also brief summary of individual replies hereafter).

I) and II). *Material used and design of packing.*

The majority of Administrations are using C. I. packings of orthodox designs, and of such types as the « Britimp », « Britallic » and « United Kingdom ». The South African and Japanese Government Railways are using an alloy of lead and copper in the form of a three-piece self-adjusting packing held together on the rod with garter springs.

III) and IV) *Lubrication and life of packing.*

The cast iron packings in the main rely on cylinder lubrication and on the swab lubrication of the rod, with the exception that on the L. M. S. oil from the mechanical lubricator is taken to the inside of the stuffing box. The life in terms of mileage varies from 33 000 to 95 000.

The copper-lead alloy packing on the Japanese Government Railways is lubricated directly with cylinder oil from an oil box by means of wool trimmings. The life is given at approximately six years. The South African lead-copper

alloy relies on piston rod lubrication only, and the life for valve spindle and piston packings is approximately 18 000 and 20 000 miles respectively.

* * *

SUMMARY OF INDIVIDUAL REPLIES (CHAPTER 4, QUESTION 2).

2. What new types of packing are used at the present time in conjunction with superheated steam ?

Buenos Ayres and Pacific. — For new engines, « Britimp » C. I. split packing. Other packings in use with superheated steam are of orthodox design, made of bronze.

Central Argentine. — « U. K. ».

Southern. — « U. K. ».

South African. — Two types : Three-piece packing, and a modified form of « U. K. » packing.

Great Indian Peninsula. — « Britimp » and « Britallic ».

Japanese Government. — Three-section self-adjusting ring packing in duplicate. Each ring is held in position on the rod by means of a garter spring. Used for valve spindles and piston rods.

Please give the following information for each type used :

(I) Material used for the packing.

Buenos Ayres and Pacific. — Bronze packing : 70 % copper, 25 % lead, 5 % tin.

Central Argentine. — Cast iron.

Baltimore and Ohio. — See Appendix D/1.

London Midland and Scottish. — *a*) White metal for valves; *b*) Cast iron for pistons.

Southern. — Cast iron.

Nigerian. — White metal.

South African. — Lead-copper alloy, 66 %, lead, 35 % copper, 1 % sulphur, used for both types.

Sudan. — Metallic packing, air-cooled.

Great Indian Peninsula. — Cast iron.

Japanese Government. — Copper-lead alloy.

(II) Design of the packing (attach drawing).

Central Argentine. — Three-segment ring packing with garter spring.

Baltimore and Ohio. — See Appendix D/1.

London Midland and Scottish. — Orthodox design.

Southern. — Three-segment ring packing, with double garter spring.

South African. — « U. K. » type, three-segment ring packing with garter spring. Three-piece type, see Appendix D/3 for drawing.

Great Indian Peninsula. — « Britimp » and « Britallic » split rings with garter springs.

Japanese Government. — See diagram, Appendix D/4.

(III) Lubrication of the packing (details of lubricant and method).

Central Argentine and Baltimore and Ohio. — Rely on cylinder lubrication.

London Midland and Scottish. — Mechanical lubrication to inside of stuffing box. See Appendix D/2 for lubricant used.

Southern. — Piston rod lubrication. Engine oil used.

Nigerian. — Superheater oil from sight feed lubricator.

South African and *Great Indian Peninsula.* — Piston rod lubrication.

Japanese Government. — Wool trimming from oil box. Cylinder oil used.

(IV) Total life of packing (i. e. between complete renewal) in miles.

London Midland & Scottish. — White metal 15 000 to 20 000 miles. Cast iron 33 000 miles.

Southern. — Greatest recorded mileage 287 000 miles. Average about 95 000 miles.

Nigerian. — 11 000 to 20 000 miles, according to class of engine.

South African. — Piston packing, approximately 20 000. Valve spindle packing, approximately 18 000.

Great Indian Peninsula. — Average 70 000 miles.

Japanese Government. — Approximately six years.

* * *

CHAPTER FIVE.

Feed water pre-heating since 1930.

1 and 2. New designs of feed water heater and the number of engines fitted.

Trials of A. C. F. I. feed heaters are being made by five Administrations, with a total of 25 engines fitted, 16 of which are on the Great Indian Peninsula Railway, 4 in the Sudan, 3 on the L. M. S. R., and one each on the Buenos Ayres and Pacific, and the L. N. E. R.

Gresham feed heaters are on trial on one Buenos Ayres and Pacific engine, and following a trial in 1933 on the Nigerian Railway, 12 more engines of the latter Company have now been fitted.

The Japanese Government Railways have 790 engines fitted with a closed type multi-tube heater.

The Great Indian Peninsula Railway reports the fitting for trial of two « Dabeg » and two « Heinl » feed heaters.

3. Tests carried out and results obtained.

The dynamometer car trials on the G. I. P. Railway have resulted in savings of 8.5 % in coal, and 8 % in water being realised with A. C. F. I. over live steam injectors. Tests on the L. M. S. R. with the same type of heater shew that 0.046 lb./ton-mile coal, and 0.387 lb./ton-mile water, were consumed on a test with a 900-ton freight train inclusive of the engine. The coal figure represents a saving in favour of A. C. F. I. of 4 % over exhaust injectors, and 9 % over live steam injectors.

The Japanese Government Railways with their multi-tube feed heater on line tests give the coal consumption as 0.096 lb./ton-mile, and the water as 0.76 lb./ton-mile, exhibiting a saving in favour of the feed heater of 7.7 % coal, and 5 % water, when compared with live steam injectors.

Although the Baltimore and Ohio have not adopted any new designs of feed-water heater, line tests with an « Emerson » closed type heater and duplex feed pump have established the following figures : 0.069 lb./ton-mile coal, and 0.500 lb./ton-mile water, shewing savings in coal of 6.75 % over exhaust injectors, and 20.7 % over live steam injectors. The water consumption shews that the feed heater was heavier than the exhaust injector by 6.66 %, which figure, however, does not include water reclaimed from the exhaust by exhaust steam injector. When compared with the live steam injector, the feed water heater shews a saving of 18.4 % (*see also Appendix E/1*).

The Nigerian Railway reports a slight decrease in coal consumption in favour of feed heaters when compared with engines not so fitted.

4. Maintenance costs compared with exhaust and live steam injectors.

The report of the G. I. P. Railway states that maintenance costs per mile with A. C. F. I. over a mileage of 101 000 are greater than they are with live steam injectors over a mileage of 720 000. From these figures it is shewn that an engine fitted with A. C. F. I. and one live steam injector is 29.7 % heavier in maintenance than an engine fitted with two live steam injectors.

The L. N. E. R. have found that the cost of maintenance is greater than with exhaust or live steam injectors.

5. Advantages and disadvantages of feed heaters and exhaust and live steam injectors. Influence on scale formation in boiler.

The Baltimore and Ohio, and Reading

Companies give the live steam injector the advantages of reliability and accessibility, the former Administration claiming that with treated waters the disadvantage of scale formation, usually associated with the live steam injector, does not exist.

The L. N. E. R. find that the saving in fuel consumption of A. C. F. I. is neutralised by the increased cost of maintenance.

The Nigerian Railway reports reduced scale formation with engines fitted with feed heaters.

The opinion expressed by the G. I. P. Railway is that A. C. F. I. feed heaters, correctly handled, are superior to injectors, that they are reasonably reliable, and that they cause less scale formation in the boiler. It has, in consequence, been possible to extend the mileage run between hot water wash-outs.

The Japanese Government Railways in comparing feed heaters with live steam injectors, state they are equally reliable and that there is no difference in the scale formation in the boiler between engines fitted with one injector and a feed water heater, and engines fitted with two injectors. These comments are based on the fact that feed water heaters, either open or closed, are fitted to nearly 40 % of their superheated engines.

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CHAPTER SIX.

Air pre-heating since 1930.

No new methods of air pre-heating are reported to have been adopted or tested by any Administration replying to the Questionnaire.

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CHAPTER SEVEN.

Improved blast pipe design since 1930.

1. New types of blast pipes.

a) Single.

« Jumper » type blast pipes are being fitted to new engines on the L. M. S. R. and to the streamlined *Pacific* engines of the L. N. E. R. The Nigerian Railway has also adopted this type of blast pipe.

The « Cruciform » nozzle has been fitted to a number of coal-burning engines on the Buenos Ayres and Pacific Railway, whilst on the Pennsylvania Railroad the ported « Star » nozzle has made its appearance on *Pacific* engines (see Appendices F/1 to F/4). It would appear that both these railways aim at obtaining a greater entrainment surface.

The Baltimore and Ohio Railroad has carried out a number of experiments with exhaust nozzles, but none has been found to give such satisfactory results as the standard in use prior to 1930. Two locomotives, used for transferring sleeping cars at terminal stations, have been fitted with variable exhaust nozzles to reduce noise. The arrangement is found satisfactory.

The Delaware and Hudson also reports that experiments are in hand with variable nozzles, which they consider essential to engines operating between cut-offs of 5 % to 60 %.

The Reading Company has fitted two engines for trial with the « Cyclone » front end arrangement.

The Japanese Government Railways have no new type, but report that research has resulted in an exact formula being worked to for orifice diameter on superheated engines with single blast pipes (see Appendix F/6).

b) Double.

« Kylchap » double blast pipes and chimneys have been fitted to three 2-8-2 passenger engines on the L. N. E. (see

Appendix F/5). The Southern Railway also has a four-cylinder 4-6-0 express locomotive fitted with this type. « Kylchap » blast pipes have been adopted for the *Garratt* engines of the Nigerian Railway.

Double blast pipes are used on the Japanese Government Railways, but are of their own design (see figure (*f*), Appendix F/6).

Two engines of the Buenos Ayres Western Railway have recently been fitted with a double blast pipe arrangement; on one engine the blast pipes are set one in front of the other, and on the other engine, across the smokebox. No further information is available.

No other types have been reported apart from the special double blast arrangement in the smokebox of the L.M.S. turbine locomotive, which is referred to in Chapter 14, Question 1 *(e)*.

2. Effect of new types of blast pipes on the emission of sparks.

The only Administrations to report a decrease in the emission of sparks are the Pennsylvania, with the ported « Star » nozzle (K4Sc. shewn in Appendix F/4), the Reading Company, with the « Cyclone » front end, and the Nigerian Railway, with both « Jumper » top on single blast pipes, and « Kylchap » double blast pipes.

3. Comparison of fuel consumptions with exactly similar engines not fitted with new types of blast pipes.

The Reading Company has realised a saving of 15 % in coal consumption by the use of the « Cyclone » front end.

13.8 % coal saving is claimed by the Nigerian Railway for the « Jumper » top over engines with single blast pipes not so fitted.

Test plant results from the Pennsylvania Railroad shew an average of 9 % coal saving with the ported « Star » nozzle (K4Sc.) over a range of cut-offs, from 25 % to 60 %.

Evaporation is improved to an extent of 3 % on the Japanese Government Railways by the adoption of double blast pipes in place of the standard single type.

The Buenos Ayres and Pacific Railway states that a slight reduction in fuel consumption has been realised with the « Cruciform » type of blast pipe nozzle.

The L. N. E. R. reports an economy in coal from the use of the « Jumper » tops, but adds that maintenance has been increased.

* * *

CHAPTER EIGHT.

Improvements in valves, pistons and valve gears since 1930.

1. Valves.

a) **Particulars of new or improved form of steam distribution and exhaust valves, number of engines fitted and results obtained.**

Poppet valves and R. C. gear.

Six Administrations have reported on their experience under this heading.

The Delaware and Hudson Railroad's two new engines, the 500 lb./sq. in. triple expansion freight engine and the 325 lb./sq. in. express passenger locomotive are equipped, but no figures of fuel and water consumption, or maintenance, are yet available. There is no improvement in the accessibility, but coasting is stated to be much improved.

The L. M. S. R. has five engines fitted, but dynamometer car tests have shewn that there is practically no fuel or water saving with poppet valves over the modern Walschaerts gear and piston valves. No maintenance costs are available and there is no marked improvement in accessibility, as the cam gear of Lentz

valves requires skilled attention. With Lentz valves fully open in mid-gear when coasting, freer running results.

The L. N. E. R. have equipped one P.2, 2-8-2 three-cylinder passenger engine, and a total of 42 D.49, 4-4-0 three-cylinder engines with R.C. gear operated poppet valves, (the D.49 engines were commenced at the latter end of 1929). Tests of these engines were carried out in 1935, and the results obtained are given under Question 3 of this Chapter. No decreased maintenance has resulted, nor is there any marked improvement in accessibility. When coasting in mid gear with open valves, freer running results.

The South African Railways have 71 engines fitted, and the higher cylinder efficiency realised has favourably reacted on the fuel and water consumption, but no data is available regarding maintenance costs. Whilst the valves themselves are more readily accessible, the actuating gear is very inaccessible. Freer running, however, results when coasting in mid-gear with open valves.

Twenty engines on the G. I. P. Railway have been fitted, and tests shew that 10 % fuel economy is realised over engines fitted with short travel valves. It should be noted that in comparing this saving with that of 8 % to 10 % realised with long travel valves over short travel valves, the boiler of the engines fitted with the long travel valves is 2 % more efficient than that fitted to the poppet valve engines. Maintenance costs are not available, but improved accessibility, together with freer running, is stated to be realised.

The Baltimore and Ohio Railroad equipped one engine with poppet valves and R.C. gear but the results obtained were not considered sufficient to justify adoption.

Poppet valves with oscillating cam gears.

The G. I. P. Railway only reports on this type, five of their engines being fitted. No fuel and water economies have been realised over engines with short travel piston valves, but maintenance has been reduced by £ 14 per engine per annum. Improved accessibility and freer running are experienced.

Caprotti valves.

Caprotti valve gear has been fitted to 20 engines of the G. I. P. 10 % fuel and water economy is claimed over engines fitted with short travel piston valves, but as 8 to 10 % is also claimed for long over short travel piston valves, it should be noted for comparative purposes, as in the case of poppet valves with R. C. gear on the G. I. P., that the boiler of the long travel valve engine is 2 % more efficient than that on which the Caprotti gear is fitted. A reduced maintenance cost of £ 14 per engine per annum in favour of Caprotti is realised, in addition to improved accessibility and freer running.

Trials have been carried out with a Central Argentine Railway 4-6-2 passenger locomotive, type P. S. 11, fitted with Caprotti gear. The coal consumption is given as 0.126 lb./ton-mile, as against 0.1585 for P. S. 10 and 0.176 for P. S. 8 engines fitted with Walschaerts gear and piston valves. See Appendix G/5 for diagram of P. S. 11 engine, and G/6 for P. S. 8 and P. S. 10 engines.

T. A. B. piston valves.

The L. M. S. has fitted inside admission type T. A. B. valves to three passenger engines of the three-cylinder type for trial, and reports that ability to coast with the valves fully open has resulted in a freer running engine.

On the L. N. E. R. ten engines at the present time are fitted with T. A. B. valves. Of these, three engines have valves of the outside admission type. Inside admission valves on express passenger engines have been found unsatisfactory owing to the distortion of the

distance pieces, which takes place when the valve heads come into contact during coasting. Inside admission T. A. B. valves have, however, been found satisfactory on 0-6-2 type suburban tank engines. With outside admission valves, the advantage of T. A. B. is marked, as when coasting the heads rest at either end of the steam chest and provide efficient by-pass through the steam chest. Trials carried out with a D. 10 type engine over a period against ordinary piston valves, shew a saving of 4.55 lb. coal/mile in favour of T. A. B. Maintenance costs have been reduced, but there is no improved accessibility. Freer running is definitely experienced. Four further engines of the D. 10 type are being equipped with outside admission T. A. B. valves.

Nicolai piston valves.

This type of valve was fitted to one engine on the L. N. E. R., but the trial was not extended.

Piston valves with narrow rings.

The broad ring piston valves on the L. M. S. and Sudan Railways are being replaced by heads with six narrow rings on the « Schmidt » type valves of the former Company, and four narrow rings on the « Robinson » type valves of the latter. The practice has been standardised on the L. M. S., whilst 73 engines of the Sudan Railways have been altered. Fuel economies, reduced maintenance and freer running in the case of the Sudan Railways have resulted.

Piston valves with two narrow « L » shaped rings.

The Buenos Ayres Great Southern have adopted as standard a design of piston valve having two narrow « L » shaped rings, divided valve head and bull ring. Up to the present 230 engines have been fitted. The valve is illustrated in Appendix G/0 to this Chapter. A reduction in fuel consumption has been realised and less wear has taken place in the motion details.

Hollow piston valves.

The Buenos Ayres and Pacific Company has standardised hollow piston valves with two narrow rings for 8″, 10″ and 12″ diameter valves, the liners having diagonal bridges on the steam ports. Fuel and water consumption figures and maintenance costs are not available but the valves are said to keep tighter, are more accessible, and the engines freer than in the case of ordinary piston valves.

Independent admission and exhaust piston valves.

Special cylinders incorporating independent admission and exhaust piston valves operated by a modified Walschaerts gear have been fitted to one engine for trial on the Baltimore and Ohio Railroad.

No data is yet available under the headings of this question, as the trial has been temporarily discontinued for certain details of the design to be further developed.

Double exhaust ported piston valves.

The Southern Railway are converting a number of their older short travel valve engines to double exhaust ported piston valves. Six engines have been converted up to the present.

Tests have shewn a saving of 3.5 lb. coal/mile over short travel piston valves, but this economy is not so great as is realised with engines having long travel valves. Maintenance costs are not available and no improved accessibility has resulted. The expansion range is greater and a freer running engine results. Blast pipe orifices have been opened out.

b) **Relation of piston valve diameter to cylinder diameter.**

The following table sets out the practices adopted by the various Administrations :

ADMINISTRATIONS.	Diameter of piston valve expressed as % of cylinder diameter.	Cylinder diameters.
Buenos Ayres Great Southern.	57.1 to 52.5	17 1/2″ to 19″
Buenos Ayres and Pacific . .	50	17″ to 25″
Buenos Ayres Western . . .	57.1 to 48.7	17 1/2″ to 20 1/2″
Central Argentine	47	17″
	50	20″
	47.6	21″
Baltimore and Ohio	44.4	22 1/2″
	52 to 43.6	23″ to 27 1/2″
	50	28″
Delaware and Hudson. . . .	58.9 to 50	17″ to 20″
	53.7 to 47.9	20 1/2″ to 23″
	51 to 44.5	23 1/2″ to 27″
	51 and under	27 1/2″ and over
Reading.	42 to 52	...
London Midland and Scottish.	50 (minimum)	...
London and North Eastern. .	48.7	18 1/2″
	42.9	21″
Great Indian Peninsula . . .	55.6	18″
	48.7	20 1/2″
	55.9	21 1/2″
	45.4	22″
	53.3 and 52.2	22 1/2″ and 23″
Japanese Government. . . .	50 (approx.)	16″ to 22 1/2″ (approx.)

2. Pistons.

e information under questions *a*) and *b*) is summarised in table form, and given below :

ADMINISTRATIONS.	*Buenos Ayres Great Southern.*	*Buenos Ayres and Pacific.*			*Buenos Ayres Western.*	*Central Argentine.*
1	2	3			4	5
Type and material of piston head.	C. S. with brass liner cast on.	C.S. with brass bull rings.			C. S. with brass liner cast on.	C. S. with steel bull rings.
Material used for the rings.	C.I.	C.I. (cylinder mixture).			C.I.	...
Number of rings per head . .	2	...			2	...
Width of ring	1/2″	1/4″	1/4″	1/4″	1/2″	...
Depth of ring.	5/8″	1/2″	9/16″	5/8″	5/8″	...
Form of cut	...	Diagonally at 45°.			...	...
Width of gap when in cylinder.	...	1/64″			...	...
Form of pegging	...	Nil.			...	...
Life of ring, miles :						
Passenger	...	20 000			...	...
Freight	...				...	...
Tail rods provided	Being removed.	Being removed.			Being removed.	...
Remarks.	...	Up to 19″ cyls.	Cyls. over 19″ to 21″	Cyls. over 21″ to 25″	...	...

2. Pistons (*continued*).

ADMINISTRATIONS.	*Baltimore and Ohio.*			*Delaware and Hudson.*	
1	6			7	
Type and material of piston head.	C.S. arranged for sectional packing.			Gun iron. Box type.	
Material used for the rings.	C.I.	C.I. bronze.	Bronze.	Gun iron.	
Number of rings per head . .	Two for pressures below 350 lb./sq. in. Three for pressures above 350 lb./sq. in.			Simple expansion engine 3	Triple expansion engine 2
Width of ring	Special design of sectional piston rings.			5/8″	Special design sectional piston rings.
Depth of ring.				5/8″	
Form of cut				At 90° to ring.	
Width of gap when in cylinder.				1/16″	
Form of pegging				Nil.	Dowel pin or spring.
Life of ring, miles :					
Passenger	25 000	No test.	No test.	Insufficient service to determine.	
Freight	5 000	17 000	80 000		
If tail rods provided	Discontinued.			No tail rods.	

ADMINISTRATIONS.	*Reading.*	*Great Western.*			*London, Midland and Scottish.*
1	8	9			10
Type and material of piston head.	C.S.	C.I.			C.I. box type.
Material used for the rings.	Bronze.	C.I.			C.I. (cylinder mixture).
Number of rings per head . .	2 and 3	...			3
Width of ring	Special design of sectional piston rings.	1/4″	1/4″	1/4″	5/16″
Depth of ring.		3/8″	1/2″	9/16″	9/16″
Form of cut		Radial cut.			Angular cut.
Width of gap when in cylinder.		1/8″ to 3/16″			3/16″
Form of pegging		Nil.			Nil.
Life of ring, miles :					
Passenger	42 000	23 000 to 30 000			23 000
Freight					
If tail rods provided	No tail rods.	No tails rods.			No tail rods.
Remarks.	...	11″ to 14″ cyls.	14 1/2″ to 18″ cyls.	Over 18″ cyls.	...

2. Pistons (*continued*).

ADMINISTRATIONS.	*London and North Eastern.*		*Southern.*
1	11	12	13
Type and material of piston head.	Forged steel combined piston rod and head. (High speed engines.)	C.I. (ordinary).	C.I. box type.
Material used for the rings.	C.I. (cylinder mixture).		C.I. (cylinder mixture).
Number of rings per head . .	2	2	3
Width of ring	5/16″	11/16″	0.248
Depth of ring.	5/8″	5/8″	0.625
Form of cut	Diagonally at 45°.	Diagonally at 45°.	Square cut ends.
Width of gap when in cylinder.	9/32″ open. 3/64″ clear of key each side.	5/16″ open. 1/16″ clear of key each side.	1/16″
Form of pegging	3/16″ steel key welded, 120° apart.	3/16″ wide brass key. 120° apart.	Nil.
Life of ring, miles : *Passenger* . . . . . *Freight*	30 000		Shops to shops. Some cases after 25 000.
If tail rods provided	No tail rods.		Discontinued.
Remarks.	...		...

ADMINISTRATIONS.	*Nigerian.*	*South African.*	*Sudan.*	*Great Indian Peninsula.*	*Japanese Government.*
1	14	15	16	17	18
ype and material of piston head.	C.I.	Two riveted steel discs clamped on double cones.	C.I.	C. I. with bronze or C.I. bull rings.	C.S. and forged steel.
[aterial used for the rings.	C.I. (cylinder mixture).	C.I.	C.I.	C.I. (cylinder mixture).	C.I.
umber of rings per head . .	2	3	2	2	3
Vidth of ring	3/4″	3/8″	5/16″	5/16″	25/32″
epth of ring.	1/2″	3/4″	5/8″	5/8″	19/32″
orm of cut	At 90° to ring.	Diagonally at 45°	Diagonally at 45°	Diagonally at 45°	Step cut.
Vidth of gap when in cylinder.	1/16″	1/16″	1/16″	1/16″	3/64″
orm of pegging	Nil.	Nil.	Nil.	Nil.	Nil.
ife of ring, miles : *Passenger* . . . . . *Freight*	10 000 6 000	Shops to shops.	26 000	2 000 ...	31 000 15 500
tail rods provided	No tail rods.	No tail rods.	No tail rods.	No tail rods.	Tail rods are fitted.
emarks.	...	...	...	...	When tail rods are not provided, C.I. heads are used.

Apart from the practice in America of using cast steel heads arranged for sectional piston rings, C.I. heads with two or three narrow rings seem to have been generally adopted.

See Appendix G/1 for design of sectional piston rings on the Baltimore and Ohio Railroad.

See Appendices G/2 and G/3 for specification of steel and design of the combined piston rod and head, L. N. E. R.

3. Valve gears.

a) New and special valve gears.

In addition to the valve gears necessarily dealt with under the heading of « Valves » (Question 1 of this Chapter), the Buenos Ayres and Pacific Railway reports the fitting of independent Walschaerts gear to twelve three-cylinder suburban tank engines built in 1930. The centre valve is driven by the Stephenson-Molyneux modification of the Walschaerts gear.

Recent tests on the L. N. E. R. have shewn 4-4-0 and 2-8-2 three-cylinder engines fitted with piston valves operated by Walschaerts/Gresley gear to be lighter in fuel consumption than similar engines fitted with poppet valves operated by R. C. gear.

b) Valve event tables.

Tables of valve events with the different gears mentioned in this Chapter are given as Appendices :

Rotary cam poppet valve gear.

Delaware and Hudson Company . . . Appendix G/8.
London Midland and Scottish Railway . Appendix G/9.
South African Railways . . . . . Appendix G/10.

Caprotti gear.

Central Argentine Railway . . . . . Appendix G/7.

Walschaerts gear, and Stephenson-Molyneux modification.

Buenos Ayres and Pacific Railway . . Appendix G/4.

* * *

CHAPTER NINE.

Particulars of drop in steam pressure between boiler and cylinder at various cut-offs and speeds.

The following table gives particulars of the drop in steam pressure between boiler and steam chest at various cut-offs and speeds obtained with L. N. E. R. engine No. 2.001 « Cock o' the North » (2-8-2) on the testing plant at Vitry in 1934/35.

Cut-off.	Speed.	Boiler pressure.	Steam chest pressure.	Pressure drop.	Remarks.
%	m.p.h.	lb./sq.in.	lb./sq.in.	lb./sq.in.	
12	37.28	212.5	206	6.5	Average of 4 tests.
12	49.7	211.75	204	7.75	Average of 4 tests.
12	62.13	212	204	8.0	Average of 3 tests.
12	74.54	212	204	8.0	...
18	37.28	213	203.9	9.1	Average of 2 tests.
18	49.7	213	201.5	11.5	...
25	37.28	209.25	199	10.25	Average of 2 tests.
25	49.7	213	199	14.0	...
35	37.28	205	193	12.0	Average of 2 tests.

a) **Improved regulator or steam collector. openings.**

The Reading Company have introduced a double seated poppet valve type regulator. The L. N. E. R. use a double seated balanced regulator in conjunction with a steam collector fed by slots in the upper portion of the barrel plate, providing an opening 100 % greater than the cross sectional area of the steam pipe. A drawing of this arrangement is given in Appendix H/2.

Reduced steam resistance is claimed by the South African Railways from the use of an « M. L. S. » multiple valve regulator header.

b) **Increased cross section of the steam pipe.**

The L. N. E. R. has increased the cross sectional area of the smokebox steam pipes from 15.9 to 19.63 sq. in. (4 1/2″ to 5″ diam.) on Pacific type engines.

The Great Indian Peninsula Railway reports an increase from 17.7 to 28.2 sq. in. (4 3/4″ to 6″ diam.) in the smokebox steam pipe cross section on 20 4-6-0 and 20 2-8-0 engines, which has resulted in a reduced fluctuation of steam chest pressure.

c) **Increased area of steam passages in header and total cross-sectional area of elements.**

The Central Argentine Railway, in 1932, reduced the thickness of the elements of their superheaters from 9 to 10 S. W. G. The effect of this reduction was to give an increased steam area through the elements. Higher superheat was realised and there was a decreased drop through the superheater.

The Baltimore and Ohio provides liberal passages in the header and has standardised 1 1/2″ o.d. elements, as no material increase in superheat was obtained when 1 3/4″ o.d. elements were

tested. A statement setting out the relationship of steam areas is given in Appendix H/1 for a selection of engines of this Railway.

The L. M. S. report that on their older types of engine the cross-section of elements varied between 80 % and 150 % of the cross-section of the main steam pipe. On later engines the ratio is not less than 100 %.

On the L. N. E. R. the cross-sectional area of the 43 elements 1 1/4" (i.d.) is 52.96 sq. in. with 38.48 sq. in. cross-sectional area (7" diam.) of main steam pipe, or 137 %. Appendix H/3 is a statement giving steam areas, clearance volume, etc., on the P. 2, R. C. gear, 2-8-2 engine, « Cock o' the North ».

The Great Indian Peninsula Railway reports no increase in cross-section of the steam pipe or header. The cross sectional area of the elements expressed as a percentage of cross-sectional area of the main steam pipe is 85 % to 95 %.

* * *

CHAPTER TEN.

Streamlining.

a) **Types of locomotives, streamlined when built or subsequently converted to streamlining.**

Locomotives streamlined when built :

Only the London and North Eastern Railway and the Japanese Government Railways have designed and constructed (in 1935) streamlined locomotives as such. The L. N. E. Company's engine is the A. 4 Pacific type engine designed for high-speed running on the « Silver Jubilee » and other express passenger trains. The Japanese Government Railways' streamlined locomotive is also of the Pacific type (C. 55).

Photographs of both these engines appear as Appendices J/2 and J/3 to this Chapter, whilst outline diagrams are reproduced as Appendices L/23 and L/30 (Chapter 12, Part Two of this report).

Locomotives subsequently converted to streamlining :

The Pennsylvania Railroad streamlined, in 1936, a Pacific locomotive designed in 1930. The only other engine converted to full streamlining is a C. 53 type Pacific of the Japanese Government Railways.

Photographs of each of these engines appear as Appendices J/1 and J/4 to this Chapter. A diagram of the Pennsylvania Pacific locomotive is also included in Appendix J/1.

Two American Railways, the Baltimore and Ohio and the Reading Company, have applied streamlining to parts of locomotives, the former Administration having prepared designs for streamlined locomotives which, however, they did not adopt.

b) **The design of streamlined parts.**

I) and II) *The front end, footplate section and outside motion casing.*

The Pennsylvania Railroad employs a hemispherical cowling for the front end, a level footplate, skirting for the motion and a smoke deflector plate in line with the chimney, whilst the L. N. E. R. have adopted a horizontal wedge-form for the front end and an « aero-foil » section for the footplate and outer motion casing.

The Japanese Government Railways on both their engines use the sloped front and « aero-foil » form over buffer beam.

III) and IV) *The cab front and the tender.*

In every case the front of the tender follows the line of the cab, but fairing between cab and tender is provided only in the L. N. E. R. and Pennsylvania designs.

The Pennsylvania and Japanese Government Railways favour a high footplate level, practically on a line with

the base of the side windows of the cab. The L. N. E., on the other hand, are able to incorporate a steep vertical wedge form for the cab front, owing to the relatively lower footplate level.

The cab windows are, in every case, sloped to reduce air resistance.

A notable feature of the Japanese Government Railways' converted engine is that the tender is completely streamlined.

c) **Comparative trials of converted streamlined engines with similar engines not streamlined.**

The L. N. E. R. reports that tests carried out at the National Physical Laboratory on scale models, 3/4″ to 1 foot, of streamlined and ordinary type *Pacific* engines indicate that on streamlined engines, the saving in horse-power to overcome head-on air resistance is as follows :

Speed, m.p.h.	80	90	100	110	120	130	140	150
Saving, h.p.	97	138	190	253	327	416	520	639

The Pennsylvania Railroad reports that tunnel tests indicate a saving of 296 h.p. at 100 m.p.h. No actual tests on the road, however, have been carried out.

The greater saving shewn by the Pennsylvania Railroad (i.e. at 100 m.p.h.) is due to the greater height and width of their engine as compared with that of the L. N. E. R.

The Japanese Government Railways have carried out road tests and state that since the maximum speed of trains is limited to 95 km. (59 miles) per hour the maximum economy in coal consumption was not attained.

2. **Tests with actual locomotives streamlined, or with models in wind tunnels.**

No preliminary tests were carried out with locomotives streamlined, but the shape of the envelope of the Pennsylvania Railroad locomotive was fixed after a series of tests with 1/2″ to 1 ft. scale clay models.

Wind tunnel tests with models (scale 3/4″ to 1 foot) were made by the L. N. E. R. to ensure that with the external form adopted the smoke was thrown clear of the cab windows, and to ascertain the saving in horsepower required to overcome head-on air resistance.

3. **Effect of streamlining on accessibility.**

The Pennsylvania, L. N. E. and Japanese Government Railways report decreased accessibility, but the Pennsylvania and Japanese Government Railways streamline well below the footplate, whereas the L. N. E. R. only encase the motion to within 7″ of the wheel centres. The provision of adequate access doors tends to reduce the inaccessibility.

4. **Effect of streamlining on the temperature of moving parts.**

The Pennsylvania Railroad reports that up to the present no temperature difficulties have been encountered. The Japanese Government Railways on the other hand, record a tendency for the oil temperature in oil cups, and at points under the streamline envelope, to rise.

The L. N. E. R. has found it advisable to provide efficient lagging for the back of the middle cylinder to avoid heat transference to inside crosshead and slide bar, and the viscosity of the lubricating oil has been raised.

A. — Special steels (other tha

1. — Use o

a) **Particulars of new special steels adopted.**

The following table gives the types of new special steels adopted b

Parts for which special steels are used.	*Delaware and Hudson.*	*L.M.S.R.*	*L.N.E.R.*
(I) Coupling rods / Connecting rods	Special nickel - manganese. (See Appendix K/1).	Manganese - molybdenum (See Appendix K/2).	Nickel - chrome - moly denum (See Append K/6).
(II) Valve gears	...	...	...
(III) Frames.	...	High tensile (See Appendix K/3).	...
(IV) Springs.	...	Silico-manganese (See Appendix K/4).	...
(V) Spring hangers.	...	Manganese-molybdenum (See Appendix K/5).	...

b) **Weight economy.**

Weight economy realised with special steels.	*Delaware and Hudson.*	*L.M.S.R.*	*L.N.E.R.*
(I) Coupling rods / Connecting rods	No information.	14 % Rectangular section. / 20 %	Recent inclusion of m lybdenum in nicke chrome steel has n further reduced weigl Nickel-chrome rods a 30 % lighter tha straight carbon.
(II) Valve gears	...	...	...
(III) Frame	...	11 %	...
(IV) Springs.	...	Not given.	...
(V) Spring hangers.	...	11 %	...

LEVEN.

aneous.

n the boiler) and light alloys.

pecial steels.

he various Administrations :

Southern.	*Great Southern of Ireland.*	*South African Railways.*	*Japanese Government Railways.*
Vibrac » (See Appendix K/7).	...	« Supertough » (or similar).	...
			Nickel-chrome and carbon-vanadium for piston and connecting rods (see Appendix K/8).
« Vibrac » (See Appendix K/7).	...	...	...
...	« Ducol »	...	...
...	...	...	Silico-manganese, (See Appendix K/9).
Puddled iron.	...	...	...

Southern.	*Great Southern of Ireland.*	*South African Railways.*	*Japanese Government Railways.*
25 % to 30 %.	...	No information, but introduced for weight reduction reasons.	...
	...		10 % (Piston rods, 10 %).
...	...	...	...
...	Nil.	...	...
...	...	...	More than 10 %.
...	...	...	...

c) **Financial aspects.**

Generally speaking, special steels have not been adopted for direct financial advantage. High tensile steels are, of course, much greater in first cost than carbon steels, but their advantage lies in the reduced weights of reciprocating parts made possible by the use of less massive sections for equal strength, with resultant beneficial effect on hammer blow. Also, improved mechanical properties in the case of spring plates and frames, with their effect on wear and tear and resistance to fatigue, give them an indirect financial advantage.

No Administration reports the discontinuance of the use of the special steels they have adopted, except the Japanese Government Railways. In this case, an extension of their use for rods is not anticipated, but for springs their adoption is gradually increasing.

2. **Use of light alloys.**

a), b), c), d) and e) **Parts made of light alloys, results obtained, life, action of steam or hot water, weight economies and financial aspect.**

Four Administrations only report on the experimental use of light alloys.

The Delaware and Hudson employed aluminium for the brake cylinder of the coupled wheels, main reservoir and cab of their new 4-6-2 express passenger locomotive, solely to meet weight requirements at rail. A weight economy of 59 % was realised with these details, but insufficient length of service of the engine precludes any answer on life and financial aspects being given. The parts concerned are not subject to the action of steam or hot water.

The L. M. S. R. fitted one shunting engine with aluminium coupling and connecting rods, cross heads, slide blocks and piston rods and heads. The life of the last three items was short owing to the excessive wear. A number of engines were fitted up with heating pipe couplings of light alloy, upon which no apparent action by steam or hot water has taken place. On the shunting engine the weight reduction has resulted in beneficial effect upon hammer blow, but the financial aspect of light alloys in general has not yet been examined.

In 1931 Hiduminium was tried by the L. N. E. R. for piston valve heads and motion levers of a 2-6-0 three-cylinder engine and for the connecting rods of a 2-8-0 three-cylinder engine, both of which were fitted up with Gresley gear. The connecting rods are still in use and are satisfactory, but the piston valve heads were not found entirely satisfactory. Weight reductions over carbon steel of 67 % for inside, and 50 % for outside connecting rods were realised, but the cost of Hiduminium is approximately two and a half times that of carbon steel.

The report of the South African Railways refers to the experimental use of duralumin for cross head shoes, foot plates and cab walls, but no further information is given.

B. — Bearings and bearing metals.

1, 2, 3 and 4. — **Ball and roller bearings—Application, maintenance and financial aspect.**

Roller bearings of the more usual journal type were fitted to the tender wheels of some Baltimore and Ohio Railroad engines in 1927. They are giving satisfactory service and no heating cases have occurred in 300 000 miles. No special difficulties in application or maintenance have been encountered, but no information is given as to a possible extension of their use. Roller bearing wheels (on fixed axles) were tried under the tender of an engine of the same Railway in 1930, but these proved unsatisfactory, resulting in failures and increased maintenance. They were removed in 1936.

The Delaware and Hudson Company have equipped two freight and five passenger engines with roller bearings to the coupled axles, one six-wheel tender with roller bearings to the axles,

one freight and two passenger engines with roller bearings to the connecting rod large ends and side rods, and one passenger engine with roller bearing eccentric sheaves. In each case the service obtained, though limited, has been satisfactory, but two cases of delay in 250 000 miles have occurred with the connecting and side rod bearings giving trouble. It is too early to say the effect on maintenance, but, as an indication of future policy, the Company state that main axles of repaired passenger engines are being equipped and no difficulties have yet been experienced in the application of roller bearings.

The Pennsylvania Railroad have fitted roller bearings to the coupled axles of two locomotives for trial. This Company has standardised the fitting of roller bearings to carrying axles, and all engines are being equipped gradually. Maintenance costs have been reduced and the bearings have given satisfactory service. Roller bearings have also been applied to the connecting rod large and small ends of one locomotive, but slight trouble was experienced. The design is being modified to overcome this. In this case also, there is every indication that maintenance has been decreased.

The L. M. S. turbine locomotive is fitted with roller bearings to all axles and the results obtained have been quite satisfactory from the lubrication aspect. Extensive alterations to existing locomotive frames are necessary to accommodate the large housings necessary for axle bearings of this type.

Five 4-6-2 passenger engines on the L. M. S. have been fitted with needle roller bearings to the inside and outside motion pins and self-aligning ball bearings to the return crank pins for the eccentric rods. Longer periods between oiling have been realised, but overall dimensions in motion parts have had to be increased to accommodate the housings. No special difficulties in maintenance have been found, but experience is as yet too limited to express any opinion as to the extension of the use of ball and roller bearings generally.

On the L. N. E. R. ball and roller bearings are standard on the Walschaerts/Gresley valve gear and satisfactory service and decreased maintenance have resulted. No special difficulties have been met with in the application of such bearings and the use on valve gear parts is justified financially. Trials are in hand with ball bearing drive for mechanical lubricators, and so far the results obtained have been quite satisfactory.

The Great Southern Railway of Ireland reports the fitting for trial of roller bearings to carrying and tender wheels, but no other information is given.

On the Nigerian Railway, roller bearings have been applied to carrying axle journals and, since 1929, to the « two-to-one » lever of Gresley gear, three-cylinder engines. Satisfactory results have been obtained in the latter case, and no special difficulties of application have been encountered. The fitting of roller bearings to carrying axles is stated to be an advantage, as bronze was found not to stand up to the wear and tear.

Roller bearings on the South African Railways have been applied for trial to the trailing carrier and bogie axles of two locomotives and ball bearings to the R. C. gear, with which 71 engines are fitted. No details are yet available as regards maintenance, as experience is too limited at present.

The Sudan Railways report the application of roller bearings to the return cranks, but as sand found its way into the bearings, severe wear resulted. No financial advantage was realised.

Bogie and tender axles on one 4-6-0 Great Indian Peninsula Railway passenger engine have been fitted with roller bearings. These bearings have given no trouble and run at a much reduced temperature in comparison with oil lubricated white metal bearings and grease lubricated bronze bearings. No

report is made as to the possible extension of the use of this type of bearing.

5. New systems of lubrification tried and found satisfactory.

a) For axleboxes of coupled wheels.

The Baltimore and Ohio Railroad are using the Hennessey patent underfeed pad lubricator, in which a pump is incorporated.

On the L. N. E. R. the « Fountain » type lubricator has been adopted for a number of engines. This lubricator works on the full oil pipe delivery principle, fed by gravity from an oil box in the cab, and regulated by pin trimming. The driver can give extra oil at will to any box requiring it (see Appendix K/11).

Grease lubrication is being used on the Buenos Ayres Great Southern, Nigerian, South African and G. I. P. Railways. The Buenos Ayres Great Southern and Nigerian Railways employ the « Ajax » hard grease system of lubrication.

b) For axleboxes of carrying wheels.

The Hennessey lubricator is used by the Baltimore and Ohio with carrying in addition to coupled wheels. It is also used in carrying axleboxes of the Reading Company, and a drawing of the latter Company's arrangement is given as Appendix K/10.

The L. M. S. R. employ a felt pad lubricator to the underside of the journal.

The L. N. E. R. have adopted underjournal Armstrong oiler lubrication (no top lubrication is provided in these cases).

The Southern Railway reports that trials are in hand with the « Isothermos » principle on tender axleboxes.

The South African Railways employ hard grease.

c) For connecting and side rod bearings.

The Buenos Ayres Western, Buenos Ayres and Pacific, South African and Sudan Railways are, in varying degree, using grease lubrication for connecting and side rod bearings.

Single pin trimmings with felt pads are used by the Central Argentine, the L. M. S. and L. N. E. Railways. Felt pads are used on the Baltimore and Ohio, Southern and (on trial) on the South African Railways, but no specific mention is made of the type of trimming employed.

6. New lubricants used.

a) For axle and crank pin bearings (white metal and bronze).

Hard grease is used for coupled axleboxes on the Buenos Ayres Great Southern and for connecting and side rod bearings on the Buenos Ayres and Pacific, grease blocks on the Nigerian Railway and in the Sudan grease is used on white metal and bronze crank pin bearings. The Buenos Ayres Western are employing soft grease for connecting and side rod bearings on a number of engines.

On the L. M. S. dark mineral oils have been introduced, blended with 10 % rape for freight engines and 20 % rape for passenger engines. Tank engines run on the straight mineral oil.

The L. N. E. R. has adopted a red mineral oil with 25 % fat oil. The viscosity of the blended oil at 70° F. is 2 200 Redwood seconds, and at 140° F. 250 seconds. The oil is used for the A. 4 streamlined *Pacific* engines required to maintain high running speeds.

b) For axle and crank pin bearings (roller and ball).

No new lubricants have been introduced under this heading.

c) For valve gear parts and other details (ball and roller bearings).

The L. N. E. R. reports the adoption of Belmoline grease for Walschaerts/Gresley valve gear and parts. Graphited mineral oil is used in R. C. cam boxes of 2-8-2 three-cylinder engines.

7. Bearing metals now used for axleboxes, large ends and side rods.

The following table sets out the practice of each Railway replying to this question :

Administration . .	*Buenos Ayres Great Southern.*		*Buenos Ayres and Pacific.*		*Buenos Ayres Western.*		*Central Argentine*		*Baltimore and Ohio.*	
Bronze :										
Name, (if proprietary brand used).	...	...	...	...	...	..	...	...	...	...
Analysis :										
Copper . . .%	...	77	80	80	...	77	...	...	76-80	Balance
Tin . . . .%	...	8	12	12	...	8	...	...	8	4-5
Lead. . . .%	...	13	8	8	...	13	...	...	10-15	20-23
Zinc . . . .%	...	2	...	...	...	2	...	...	...	...
Impurities . .%	...	...	...	...	...	...	...	...	2	2
White metal :										
Name, (if proprietary brand used).	Stone's Railway « A » Antifriction metal.	...	...	...	Stone's Railway « A » Antifriction metal.	...	Eyre 80 % lead quality.	..	...	...
Analysis :										
Lead. . . .%	...	...	...	76	...	..	80	5.5	...	...
Antimony . .%	...	..	...	15	...	...	15	11.5	...	...
Copper . . .%	...	...	...	1	...	...	1	83.0	...	...
Tin . . . .%	...	...	...	8	...	...	4	...	...	...
Impurities . .%	...	...	...	..	...	...	...	...	...	...
Remarks.	Axleboxes and large ends.	Small end and side rod bushes.	Grease lubricated connecting rods and side rod bushes (White metal not used).	Oil lubricated axleboxes with white metal pockets.	Axleboxes and large ends.	Small end and side rod bushes.	Axleboxes.	Coupling and connecting rods.	Floating and side rod bushes.	Crown bearings.

(Continued on next page).

Bearings metals *(continued).*

Administration . .	*Delaware and Hudson.*	*Reading.*		*Great Western.*	*London Midland and Scottish.*		*London and North Eastern.*	*Southern.*	*South African.*	
Bronze :										
Name, (if proprietary brand used).	..	...	...	...	...	...	...	...	...	...
Analysis :										
Copper . . .%	77	77	80	...	...	...	86	...	88	78
Tin . . . .%	8	7	8	...	...	...	14	...	10	8
Lead . . . .%	15	15	11	...	...	...	...	...	. .	13
Zinc . . . .%	...	1	1	...	...	...	...	...	2	2 (max.)
Impurities . .%	1 (max)	...	...	. .	...	...	...	...	...	...
White metal :										
Name, (if proprietary brand used).	...	...	...	...	...	...	Loco. white bronze « C » quality. Anti-Attrition Metal Company.	...	...	...
Analysis :										
Lead . . . .%	...	...	...	28	...	75	...	5 (max.)	...	...
Antimony . .%	...	...	...	10	10	13	...	10-11	...	...
Copper . . .%	...	...	...	2	5	...	...	5-6	...	...
Tin . . . .%	...	...	. .	60	85	12	...	83-85	...	...
Impurities . .%	...	...	. .	...	...	...	...	...	...	...
Remarks.	Bronze bearing metal for axleboxes, connecting and side rods.	Axleboxes.	Large ends and side rods.	Standard mixture over a number of years.	No. 1 alloy. Coupled axleboxes, large and small ends, coupling rod bushes. High tin base to resist hammer.	No. 3 alloy. Carrying axleboxes. High lead base.	Axleboxes, large and small ends and coupling rod bushes.	White metal for bearings (Lead base metal tried but unsatisfactory).	Axleboxes.	Coupling and connecting rods.

Bearings metals *(concl.).*

Administration . . .	*Nigerian.*	*Sudan.*	*Great Indian Peninsula.*			*Japanese Government.*		
Bronze :								
Name, (if proprietary brand used).	Phosphor bronze. « Cog-wheel » brand.	...	..	...	...	...	..	...
Analysis :								
Copper . . .%	..	...	Balance	Balance	Balance	83-87	78-82	75-79
Tin . . . .%	...	...	7-11	7-11	9-11	9-11	9-11	7-9
Lead . . . .%	...	...	2.5 (max.)	16-18	9-10	4-6	9-11	14-16
Zinc . . . .%	...	...	2.5 (max.)	1.5 (max.)	0.75-1.5	...	...	...
Impurities . .%	...	...	...	...	...	1.5 (max.)	1.5 (max.)	1.5 (max.)
White metal :								
Name, (if proprietary brand used).	...	Stone's « C » quality metal.	...	...	...	...	...	...
Analysis :								
Lead . . . .%	...	...	...	...	...	...	...	...
Antimony . .%	...	...	...	...	...	...	...	...
Copper . . .%	...	...	...	...	...	...	...	...
Tin . . . .%	...	...	...	...	...	...	...	...
Impurities . .%	...	...	...	...	...	...	...	...
Remarks.	...	...	No. 2 alloy. Axleboxes.	No. 2A. alloy. Axleboxes.	No. 3 alloy. Grease lubricated big ends and side rod bushes.	No. 1.	No. 2.	No. 3.

The preceding table shews that two main types of bearing metal are used, namely, white metals, and bronzes containing lead, which if of high lead content, are known as plastic bronzes.

The white metals comprise both high lead and high tin base metals and are used in conjunction with rigid bronze or gun metal casings. Although reference is not made to the actual bearing metal used with the South African Railway's bronze for axleboxes and with the Great Indian Peninsula No. 2 alloy for axleboxes, it must be assumed that white metal of some kind is employed owing to the absence of lead in the bronze.

The Administrations using white metals are : Buenos Ayres Great Southern (for axleboxes and large ends), Buenos Ayres and Pacific (for oil lubricated axleboxes) Buenos Ayres Western (for axleboxes and large ends), Central Argentine, G. W., L. M. S., L. N. E., Southern and Sudan Railways.

The plastic bronzes vary in lead content from 8 % to 23 % and the Administrations using this type of bearing metal are : Buenos Ayres Great Southern (for small end and side rod bushes), Buenos Ayres and Pacific (for grease lubricated connecting and side rod bushes), Buenos Ayres Western (for small end and side rod bushes), Baltimore and Ohio, Delaware and Hudson, Reading, Great Indian Peninsula (with No. 2 A. alloy for axleboxes and No. 3 A. alloy for grease lubricated large ends and side rod bushes) and the Japanese Government Railways.

It will be noticed that the three American Railways replying to this question use lead-bronze exclusively, whereas the four English Railways have standardised white metal.

Generally speaking, the particular bearing metal adopted by the different Administrations is reported to be giving satisfactory results.

The phosphor-bronze (« Cogwheel » brand) adopted by the Nigerian Railway is possibly a plastic bronze in view of the fact that grease lubrication is in use on this Railway.

8. Floating bushes.

The Baltimore and Ohio, the Reading Company and the South African Railways have standardised floating bushes on outside large ends and side rods. The Delaware and Hudson Company reports that those fitted continue to give satisfaction.

The Great Indian Peninsula Railway has fitted 53 engines with these bushes and reports less wear than on solid type of brass.

The Japanese Government Railways have floating bushes under trial.

The L. N. E. R. have a limited number of *Pacific* engines fitted, but their use is not being extended.

C. — Electric welding since 1930.

1. Particulars of application in boiler construction, stress relieving and examination of joints. Financial aspect of welding in boiler construction. Weight economy.

Four Administrations employ welding in the fabrication of boilers.

The Buenos Ayres and Pacific apply welding generally in the fire area of steel boxes. Large, and small tubes of 18′ 0″ and over, are welded at the firebox end. Weight economy is not exceptional, but leakage of tubes has been greatly reduced.

On the Baltimore and Ohio stayed fireboxes are welded, but no stress relieving treatment, other than the action of the fire in service, is given. Surface inspection of the weld only is made, and the weight saving by fabrication is negligible.

The Reading Company employ the shielded arc in the fabrication of boilers by welding. No stress-relieving or X-ray examination is given, but the joints are claimed to be 30 % stronger and 10 %

cheaper than rivetted joints. There is, however, no weight economy.

The Japanese Government Railways practically completely fabricate their boilers by welding (see Appendix K/12). X-ray examination of the joints is made (see Appendix K/13). Weight and maintenance economies have been effected and repairs are stated to be easier to perform than with rivetted constructions.

The London and North Eastern Railway have fusion-welded three 5′ 6″ diameter boiler barrels for 0-6-0 goods engines, but the boilers are not yet in service. The welded barrels have been normalised and the joints X-rayed. It is not the practice to weld boilers on this Railway and the use of welding is restricted to re-inforcing mounting pads.

The Great Western Railway report the experimental use of welding for the outer casing plates of fireboxes at the foundation ring corners, and of longitudinal barrel joint re-inforcing by welding for 12″ from each end.

The London Midland and Scottish Railway confine the use of welding to re-inforcing mounting pads.

The South African Railways fabricate foundation rings from bar, and weld firedoor seams. Longitudinal seams are re-inforced on the barrel courses, but no heat treatment or X-ray examination is given and no weight economy has been realised.

2. Extent to which welded fabrication is replacing heavy iron and steel castings. Economies in weight and production costs.

The Great Western and London Midland and Scottish Railways report good progress in the welded fabrication of engine details.

The G. W. R. enumerate such items as cross-heads, valve gear brackets and water scoops, whilst the L. M. S. have fabricated drag boxes, smoke box saddles and smaller details, estimating a saving in weight over castings of 6 % to 40 %, and in cost 1 % to 60 %, the greatest savings being realised with the smaller details.

The London and North Eastern Railway has standardised welded fabrication for brake shafts, sand boxes, ash pans, etc., and designs for welded replacements of iron and steel castings, such as smokebox saddles motion plates, drag boxes etc., are being considered.

Both the L. N. E. and Southern Railways have fabricated tender tanks by welding, the L. N. E. R. experimentally. The Southern Company reports having realised savings of 2 1/2 % in weight and 5 % in cost over rivetted constructions. The Southern Railway Company have also some welded smokebox saddles.

On the American Railways, only the Baltimore and Ohio reports the use of welding, which they apply to the fabrication of frame cross-stays. Welded fabrication is also employed when single replacements of castings are needed. They have not found it economical, however, to employ welding for large numbers of casting replacements.

The Japanese Government Railways fabricate by welding only small and simple parts, with resultant weight economy of from 30 % to 40 %, the production costs being substantially reduced.

Sand boxes only are fabricated on the Nigerian Railway, and the Buenos Ayres and Pacific are considering welded fabrication in conjunction with new designs.

D. — Boiler insulation since 1930.

1. Materials found to give the most efficient service.

(See also brief summary of individual replies at the end of this Chapter.)

Analyses of the reports received shew the following statistics :

Insulating material.	Used by : Number of Administrations.
« Alfol »	5
Asbestos mattresses . . .	8
Asbestos plastic. . . .	3
Magnesium carbonate 85 %.	4
Asbestos 15 %	

A trial of rockwool by the Baltimore and Ohio Railroad is in hand.

2. Thermal conductivity.

Figures for thermal conductivity are in most cases theoretical and have not the support of practical test. It is felt therefore, that their inclusion would not be of any real value.

3. Life.

« Alfol » is expected to last from general repair to general repair.

The life of asbestos mattresses is estimated at from four to six years, and of block about three years. The L. M. S., however, give ten years as the life of asbestos.

Magnesium carbonate and asbestos has an indefinite life as it is re-used with a make-up of new.

4. Method of application.

Single sheets of « Alfol » foil are crumpled slightly and laid one upon the other between galvanised wire mesh. The mattresses so formed are placed directly on to the boiler barrel and other parts to be lagged and covered with the usual sheet steel clothing.

The methods of applying asbestos in both mattress and plastic forms are too well known to need description.

Magnesium carbonate and asbestos is moulded into blocks which are built up round the parts to be lagged.

E. — Mechanical firing since 1930.

1. Mechanical means for pushing coal forward on the tender.

Three Administrations report the adoption of some form of mechanical coal pusher.

The Buenos Ayres and Pacific, and the Baltimore and Ohio Railways employ a similar type of pusher, working on the stepped jigger principle and actuated by a small steam cylinder, controlled from the cab of the locomotive by the fireman.

The Buenos Ayres and Pacific Railway have applied the arrangement to one *Garratt* and eight 2-8-2 freight engines, and to one engine with a six-axle tender. The Baltimore and Ohio Railroad have equipped 132 non-stoker fitted passenger engines.

The L. M. S. R. has fitted 32 *Garratt* engines with a rotating coal bunker.

2. Mechanical stokers.

Three Railways only report the fitting of mechanical stokers.

The Baltimore and Ohio have fitted six locomotives, and have five more being fitted with the « Waterfall » stoker, a new design, of which the special feature is the independent drive of the elevator screw. A drawing of this stoker is reproduced as Appendix K/14. No full tests have yet been made. (This Railway has a total of 1 021 engines fitted with miscellaneous mechanical stokers.)

Ten engines of the Reading Company have been fitted with Dupont « Simplex » type B. stoker of orthodox design, but no tests have been carried out.

On the Great Indian Peninsula Railway a B. K. 1 type stoker has been fitted to one tender engine to investigate the possibilities of converting oil-burning engines to mechanically-stoked coal-burning engines. The stoker embodies a crusher in the tender, is steam driven, and discharges the fuel on to a distri-

buting tray from whence it is spread by jets over the fire bed. The stoker is capable of delivering 7 500 lb. coal per hour, and tests shew that steam pressure is well maintained but that certain losses are experienced through the grate, and smoke emission is heavy. Maintenance is also expected to be high.

F. — Oil firing since 1930.

Only the Buenos Ayres and Pacific Railway has any new developments to report.

A system of oil firing is in use in which the atomisation of the fuel by the steam jet is carried out by the steam jet impinging on the fuel as it leaves an orifice practically at right angles to the jet. A drawing of the burner is reproduced as Appendix K/15. Twenty-seven freight, sixteen passenger, and thirteen mixed traffic engines are equipped with this arrangement.

The heat value of the fuel oil is 18 260 B. T. U. with a Specific Gravity of 0.960, Flash point 150° F., and Viscosity at 100° F. of 7 200 Redwood No. 1 seconds.

No results of tests have been given, but for comparison of fuel it is usual to obtain a similar evaporation with 0.875 lb. oil to 1 lb. coal.

The Central Argentine Railway reports that all locomotives are now coal fired, and the Delaware and Hudson that no new installations have been made. The Buenos Ayres Great Southern has 470 oil-fired locomotives, and the Buenos Ayres Western, 84, but neither of these Administrations reports the adoption of any new liquid fuel apparatus.

G. — Pulverised fuel since 1930.

No Administration reports the adoption of pulverised fuel since 1930.

* * *

SUMMARY OF INDIVIDUAL REPLIES (CHAPTER 11 D).

1. **What material has been found to give the best results from the thermal and economic standpoints ?**

Buenos Ayres Great Southern. — Asbestos mattresses and asbestos cement standard.

Buenos Ayres and Pacific. — Asbestos mattresses as general practice.

Buenos Ayres Western. — Asbestos mattresses and asbestos cement standard.

Baltimore and Ohio. — Magnesia carbonate, 85 %, and fibre asbestos. Trials in hand of rockwool compressed between wire mesh.

Delaware and Hudson. — Experiments in hand with « Alfol » on one locomotive.

Reading. — Magnesia, 85 %, and asbestos.

Great Western (Gt. Bn). — Plastic magnesia and asbestos.

London Midland and Scottish. — « Alfol ». It is approximately 17 % of the weight of asbestos for similar area covered.

London and North Eastern. — Asbestos. « Alfol » foil.

Southern. — Asbestos fibre bound with silicate of soda. Plastic magnesia - 85 % magnesium carbonate, 15 % asbestos.

Great Southern (Ireland). — « Alfol ».

Nigerian Railway. — Asbestos mattresses.

South African. — « Alfol », mainly on account of weight reduction over asbestos.

Great Indian Peninsula. — « Limpet » mattresses have been largely used, but the matter is under further investigation.

Japanese Government. — Asbestos mattresses. Outer part made of asbestos plain weaving cloth, part next to boiler plates asbestos twilled cloth, or brass net mattresses stuffed with asbestos fibre. High efficiency obtained.

2. **What is the thermal conductivity of the material ?**

Baltimore and Ohio. — Thermal conductivity of 1 1/2" thickness of 85 % magnesia

is 7.19 B. T. U./sq. ft./°F. difference in temperature.

Delaware and Hudson. — 0.28 B. T. U./Hour/sq. ft./1″ thick/°F. difference at 75° F. mean temperature.

London Midland and Scottish. — Loss of heat units per unit time : « Alfol » compared with asbestos, in ratio of 35 to 40.

Southern. — Tests for thermal efficiency as follows : A 3/4″ slab of the material is wound round a 3′ 0″ long smooth steel tube, 1 7/8″ diameter × 3/16″ thick, and steam is passed through at atmospheric pressure. The condensed steam shall not exceed 40 cc. per 30 minutes.

South African. — Good insulating properties, but no data yet available for comparison with asbestos.

Japanese Government. — Heat conduction (actual) : 0.055 to 0.062 kgr./cal./mh°C. (0.218 to 0.246 B. T. U./mh°C.).

3. **What is the life of the material ?**

Buenos Ayres and Pacific. — Insufficient to determine.

Baltimore and Ohio. — Not definite, re-used constantly.

Delaware and Hudson. — Insufficient service to determine.

Reading. — Not definite, re-used constantly.

Great Western (Gt. Bn). — From repair to repair of engine. Used again with make-up of new after stripping.

London Midland and Scottish. — No data available owing to short experience with « Alfol ». (Asbestos life, 10 years).

London and North Eastern. — Asbestos mattress 4-6 years. Asbestos blocks 3 years. « Alfol » not used long enough to give figures.

Southern. — Materials are re-used with a make-up of new.

South African. — No exact information can be given, but renewal anticipated at general repairs, or if material has to be disturbed.

Great India Peninsula. — From general repair to general repair. Passenger engines 120 000 miles. Goods engines 80 000 miles.

Japanese Government. — Approximately three years, but fibre re-used indefinitely.

4. **What is the method of application ?**

Buenos Ayres Great Southern. — Mattresses laced on barrel and plastic form on firebox.

Buenos Ayres Western. — Mattresses laced on barrel and plastic form on firebox.

Baltimore and Ohio. — Plastic on irregular surfaces. Moulded blocks on barrel.

Delaware and Hudson. — Made up into panels and applied between lagging band and angles.

Reading. — Plastic on firebox. Slab form on boiler barrel.

Great Western (Gt. Bn). — Applied to boiler by hand trowel.

London Midland and Scottish. — « Alfol » enclosed in 2″ mesh, galvanised iron wire. Wired in position on boiler and covered by steel lagging.

London and North Eastern. — Asbestos in block and mattress form. « Alfol » corrugated under wire mesh.

Southern. — Asbestos : applied in mattress form. Plastic magnesia : applied in plastic state and dried out by artificial heat.

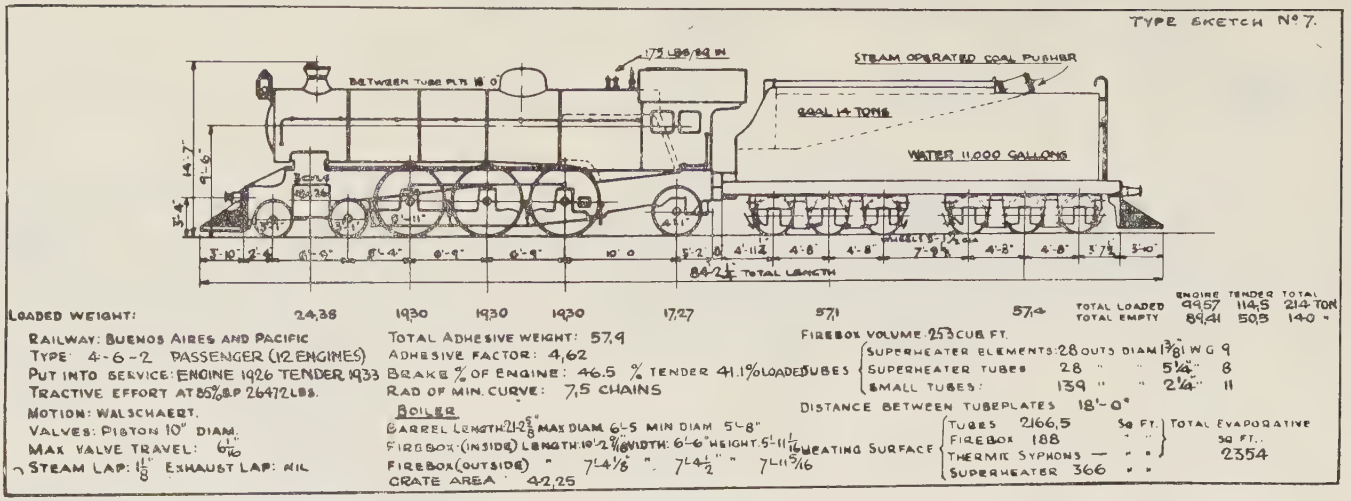
Great Southern (Ireland). — Held in position on boiler by wire mesh.

South African. — In form of wire mesh mattresses.

Great Indian Peninsula. — Mattresses are fitted under lagging plate in usual way. For trial « Limpet » asbestos has been sprayed on to firebox rear clothing plates to a distance of 1′ 0″ from the cab front on four locomotives.

Japanese Government. — Secured to boiler by lacing.

APPENDIX A/1. — **4-6-2 passenger engine.** — Buenos Ayres and Pacific Railway.


TYPE SKETCH Nº 7.
175 LBS/SQ IN
STEAM OPERATED COAL PUSHER
COAL 14 TONS
WATER 11000 GALLONS
84-2½ TOTAL LENGTH
LOADED WEIGHT: 24,38 19,30 19,30 19,30 17,27 57,1 57,4
TOTAL LOADED ENGINE 99,57 TENDER 114,5 TOTAL 214 TON
TOTAL EMPTY 89,41 50,5 140 "
RAILWAY: BUENOS AIRES AND PACIFIC
TYPE 4-6-2 PASSENGER (12 ENGINES)
PUT INTO SERVICE: ENGINE 1926 TENDER 1933
TRACTIVE EFFORT AT 85% B.P 26472 LBS.
MOTION: WALSCHAERT.
VALVES: PISTON 10" DIAM.
MAX VALVE TRAVEL: 6 1/16"
STEAM LAP: 1 1/8" EXHAUST LAP: NIL
TOTAL ADHESIVE WEIGHT: 57,4
ADHESIVE FACTOR: 4,62
BRAKE % OF ENGINE: 46.5 % TENDER 41.1% LOADED
RAD OF MIN. CURVE: 7,5 CHAINS
BOILER
BARREL LENGTH 21-2 5/8" MAX DIAM 6'-5 MIN DIAM 5'-8"
FIREBOX (INSIDE) LENGTH 10'-2 7/8" WIDTH 6'-6" HEIGHT 5'-11 15/16"
FIREBOX (OUTSIDE) " 7'-4 1/8" " 7'-4 1/2" " 7'-11 5/16"
GRATE AREA 42,25
FIREBOX VOLUME 253 CUB FT.
SUPERHEATER ELEMENTS: 28 OUTS DIAM 1 3/8" W G 9
SUPERHEATER TUBES 28 " " 5 1/4" 8
SMALL TUBES: 139 " " 2 1/4" 11
DISTANCE BETWEEN TUBEPLATES 18'-0"
HEATING SURFACE
TUBES 2166,5 Sq FT.
FIREBOX 188 " "
THERMIC SYPHONS — " "
SUPERHEATER 366 " "
TOTAL EVAPORATIVE 2354 Sq FT.

APPENDIX A/2. — **Special steels for firebox wrapper plates, longitudinal stays and « Monel » stays.**
London Midland and Scottish Railway.

2 % nickel steel. Analysis and physical properties.

Analysis.

Carbon	0.2 — 0.25
Silicon	0.1 — 0.15
Manganese	0.5 — 0.7
Sulphur and phosphorus	0.04
Nickel	1.75 — 2.00

Physical tests.

Tensile	34 — 38 tons
Elongation	22 — 24 %
Yield (% of tensile)	50
Reduction of area	50 %

Steel for longitudinal stays.

Analysis.

Carbon	0.2 — 0.25
Silicon	0.1 — 0.2
Manganese	0.85 — 1.0
Sulphur and phosphorus	0.04 max.
Chromium	0.45 max.
Copper	0.3 — 0.5

Physical tests

Tensile	28 — 32 tons
Elongation	20 %

« Monel » metal stays.

Tensile	34 — 38 tons
Elongation	35 %
Yield	15 — 18 %

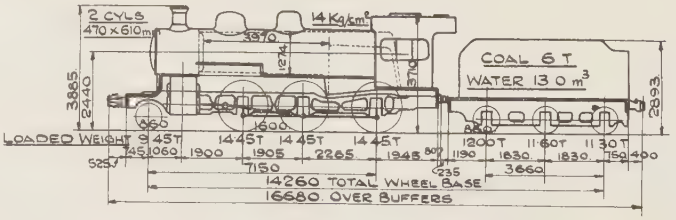
APPENDIX A/3. — 2-6-0 passenger engine, type C. 50. — Japanese Government Railways.

RAILWAY JAPANESE GOVERNMENT
TYPE C.50
2-6-0 ENGINE
YEAR BUILT 1929

WEIGHTS.

	ENGINE.	TENDER.	TOTAL.
LOADED	52 80 T	34 90 T	87 70 T
EMPTY	48 50 T	15 90 T	64 40 T

TOTAL ADHESIVE WEIGHT
43350 Kgs



BOILER BARREL 1274 mm DIA

TUBES { SUPERHEATER ELEMENTS 18
" TUBES. 18 DIA. 127 mm
SMALL TUBES 93 DIA. 93 mm.
DISTANCE BETWEEN TUBEPLATES 3970 mm.

HEATING SURFACE { TUBES 72.7 m² / FIREBOX 9.5 / SUPERHEAT 28.8 / TOTAL 111.0 } TOTAL EVAPORATIVE 82.2 m²
GRATE AREA 1.61
MOTION. WALSCHAERT

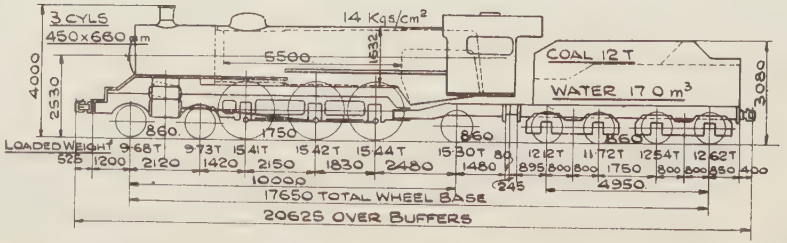
APPENDIX A/4. — 4-6-2 three-cylinder passenger engine, type C. 53. — Japanese Government Railways.

RAILWAY JAPANESE GOVERNMENT
TYPE C 53
4-6-2 PASSENGER ENGINE
YEAR BUILT. 1928

WEIGHTS

	ENGINE	TENDER	TOTAL
LOADED	80.98 T	49.00 T	129.98 T
EMPTY	72.88 T.	20.00 T.	92.88 T

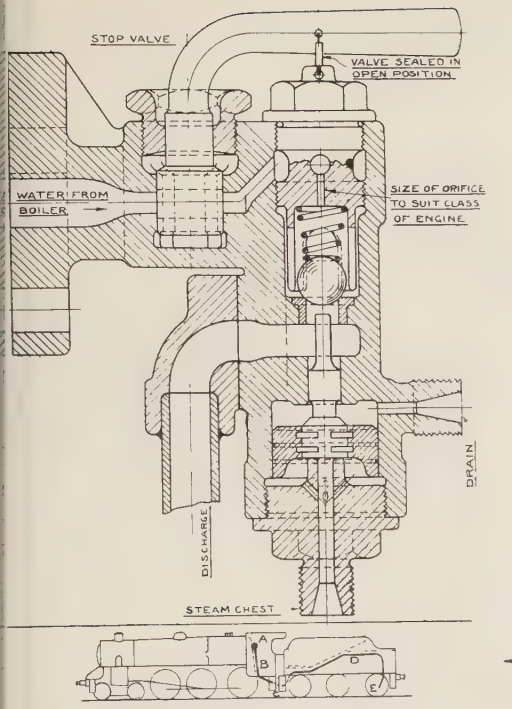
TOTAL ADHESIVE WEIGHT
46270 Kgs



BOILER BARREL 1632 mm DIA

TUBES { SUPERHEATER ELEMENTS 28
" TUBES 28 DIA 140 mm
SMALL TUBES. 88 DIA 57 mm
DISTANCE BETWEEN TUBEPLATES 5500 mm

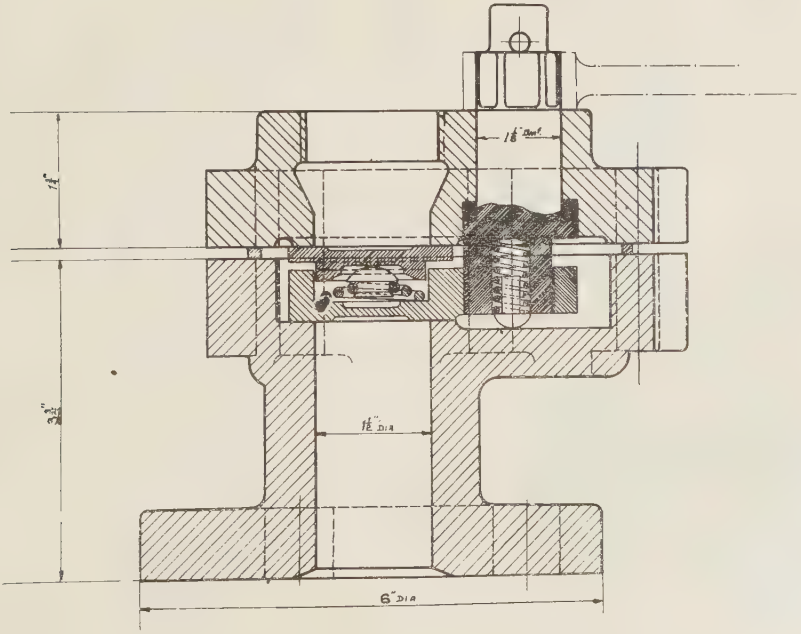
HEATING SURFACE { TUBES 142.6 m² / FIREBOX 13.5 / SUPERHEAT 64.4 / TOTAL 220.5 } TOTAL EVAPORATIVE 156.1 m²
GRATE AREA 3.25 m²
MOTION WALSCHAERT.



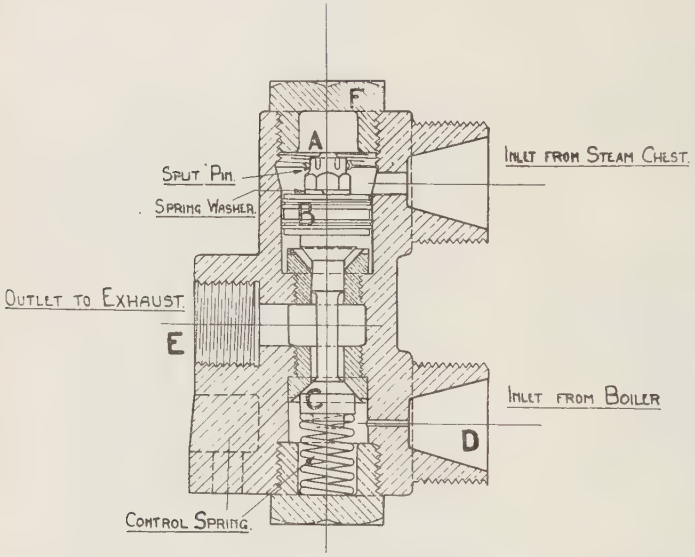
APPENDIX B/1.—Continuous automatic blow-down valve, and position in boiler from which blow-down water is taken. — London Midland and Scottish Railway.

A Blow-down valve.
B Copper discharge pipe.
C Flexible connection between engine and tender.
D Cooling pipe in tender tank.
E Discharge to track.

APPENDIX B/2. — Vertical guillotine intermittent blow-down valve.
Buenos Ayres and Pacific Railway.



APPENDIX B/3. — Continuous automatic blow-down valve. — Great Western Railway.

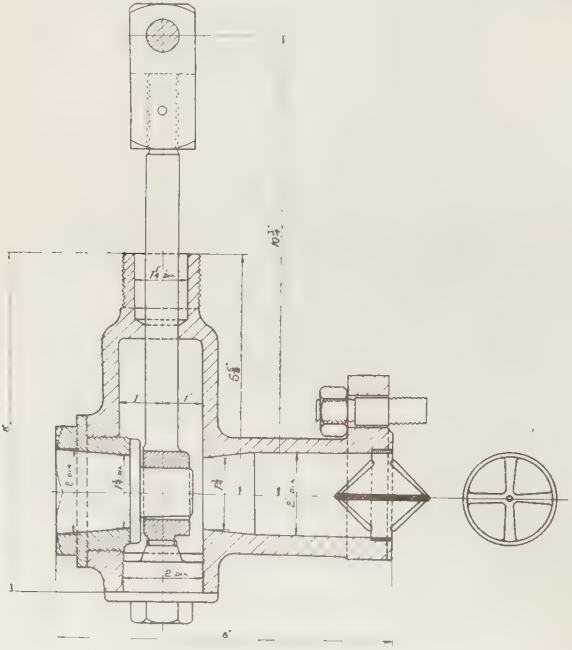


Method of operation:

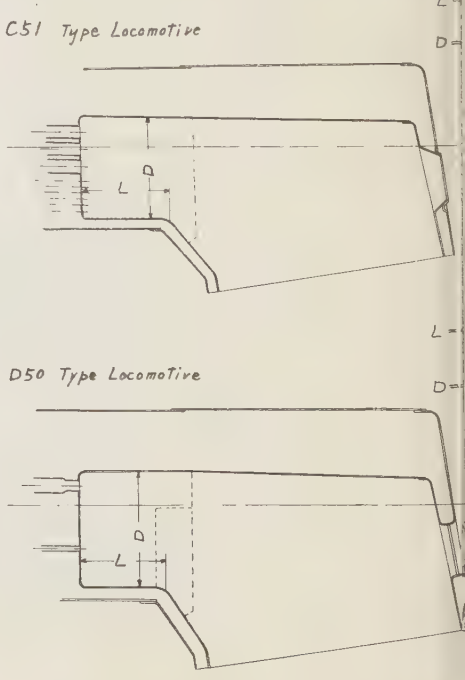
On opening the regulator valve steam is admitted from steam ches to chamber A, operating piston l thus opening valve C, and allowin the concentrate from the boile entering at D to escape throug connection E to pipe line throug tank.

On *shutting regulator valve,* *automatically closes.*

APPENDIX B/4. — « Everlasting » horizontal guillotine intermittent blow-down valve. — South African Railways.



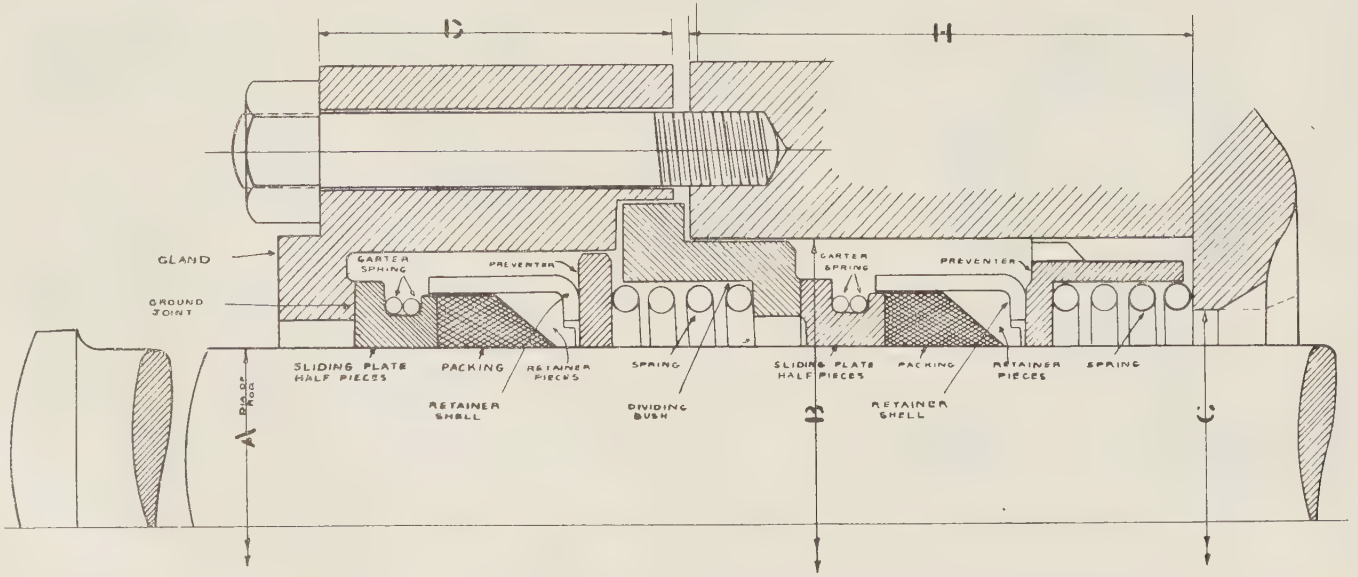
APPENDIX C/1. — Two typical combust chambers. — Japanese Government Railwa



APPENDIX C/2. — Test plant figures of smokebox gas analysis and temperatures, D. 50 type engine, with and without combustion chamber. - Japanese Government Railways.

With or without combustion chamber.	Temperature, (°C.)			Evaporative power. (kgr./kgr.) (lb./lb.)	Smokebox gas analysis (%).			
	Firebox	Smokebox	Steam		CO_2	O_2	CO	N_2
With	1036	326.0	338.3	7.41	13.60	3.90	0.50	82.00
Without	1108	341.3	349.4	7.14	14.00	3.20	0.80	82.00

APPENDIX D/1. — Tandem metallic packing for piston rods (temperature 750° F.).
Baltimore and Ohio Railroad.



APPENDIX D/2. — Specification for cylinder lubricant.

London Midland and Scottish Railway.

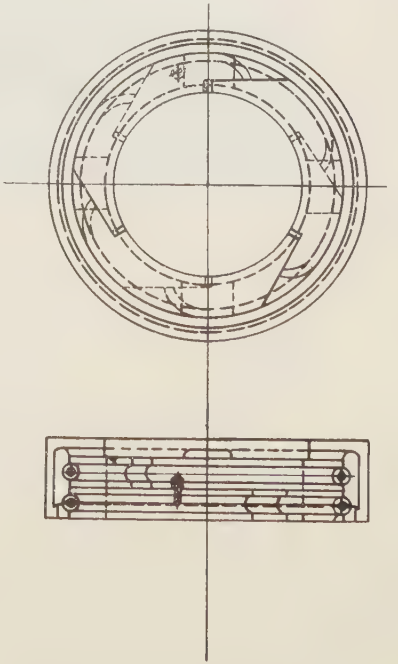
The oil to consist approximately of 95 per cent suitable dark mineral oil, and 5 per cent saponifiable oil. To be free from water, suspended matter, or other impurities.

(*) Efflux time of 50 c. cs. from Redwood viscometer.	At 140° F.	not above 920 secs.
	At 212° F.	not below 165 secs.
	At 300° F.	not below 60 secs.
Flash-point (closed test)		Not below 520° F.
Specific gravity at 60° F.		Not above 0.915.
Asphaltic matter insoluble in pentane, but soluble in benzol		Not above 1.0 per cent.

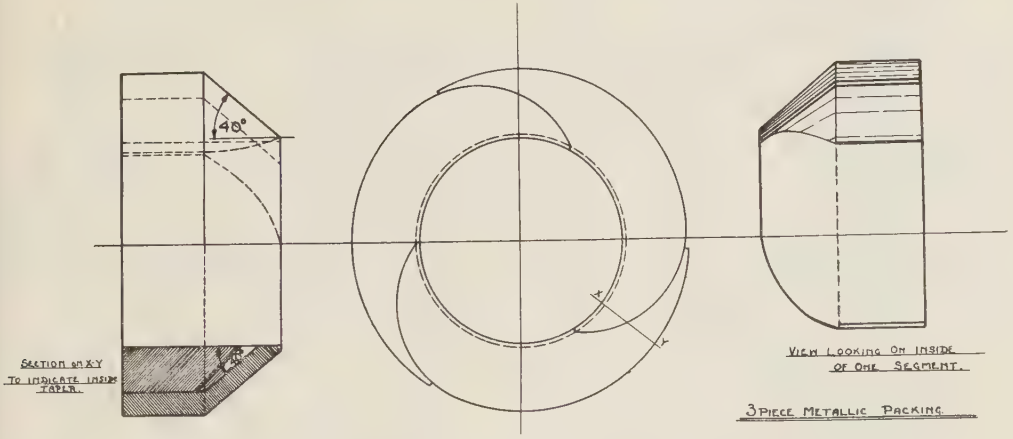
Fluidity. — Oil to the depth of 1 inch contained in a test tube 1 inch diameter shall be maintained at 60° F. for 3 hours. When the tube is inclined at 45 degrees below horizontal the oil shall not take longer than 15 seconds to flow 4 inches.

(*) Unless the thermometer used has been standardised for the conditions of immersion, the proper correction of the temperature reading must be made for the emergent thread.

APPENDIX D/3. — Three-piece self-adjusting ring packing. — South African Railways.



APPENDIX D/4. — Three-piece self-adjusting ring packing with garter spring for pistons.
Japanese Government Railways.



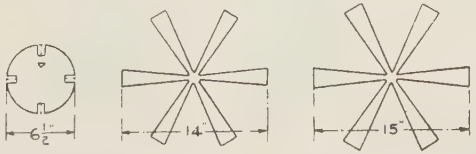
APPENDIX E/1. — Comparative tests with « Emerson » closed type heater and exhaust and live steam injectors.

Baltimore and Ohio Railroad.

Boiler feed device.	Feed water heater.	Exhaust steam injector.	Live steam injector.
Date of tests	March, 1933.	April, 1928.	March, 1933.
Kind of service	Fast freight.	Slow freight.	Fast freight.
Average coal consumed per ton-mile (*), lb.	0.069	0.074	0.087 (***)
Average water consumed per ton-mile (*), lb.	0.500	0.467 (**)	0.592 (***)

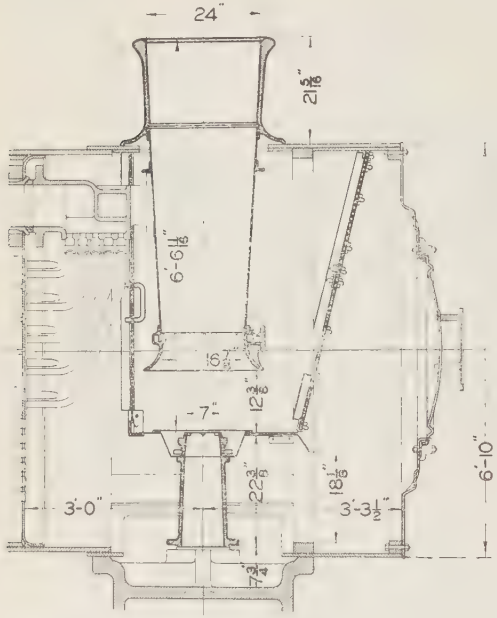
(*) Not including locomotive.
(**) Does not include water reclaimed from exhaust by exhaust steam injector.
(***) Westbound only.

APPENDIX F/1. — Circular and ported « Star » nozzles, types K4Sa, K4Sb and K4Sc. — Pennsylvania Railroad.

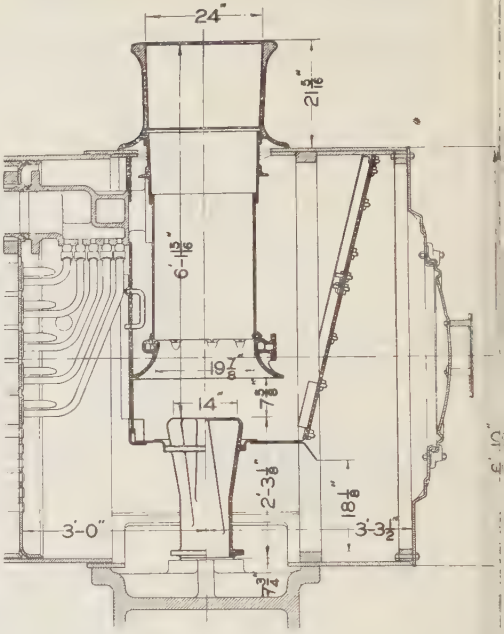


K/4 S*a* 36 sq. in. K/4 S*b* 40.3 sq. in. K/4 S*c* 47.6 sq. in.

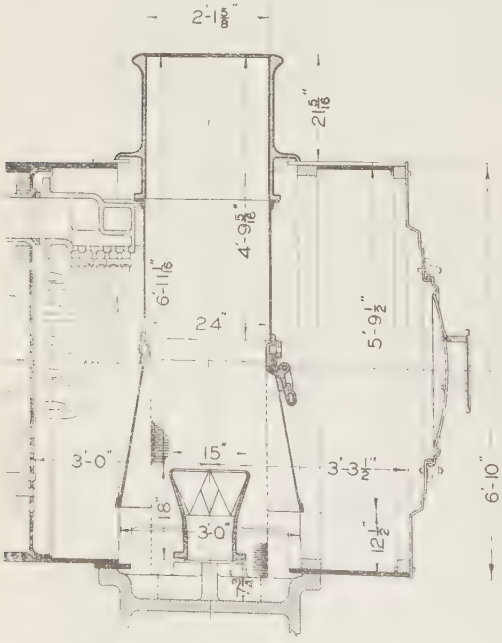
APPENDIX F/2. — Smokebox arrangement for test of circular nozzle, K4Sa. — Pennsylvania Railroad.



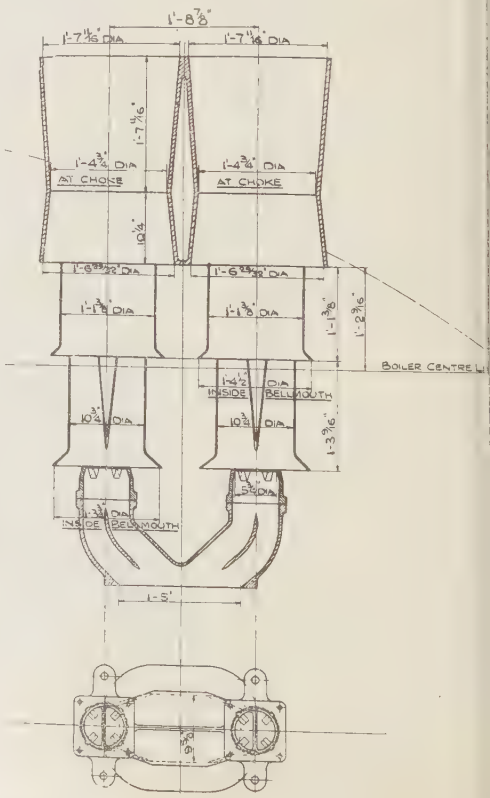
APPENDIX F/3. — Smokebox arrangement for test of « Star » nozzle K4Sb. — Pennsylvania Railroad.



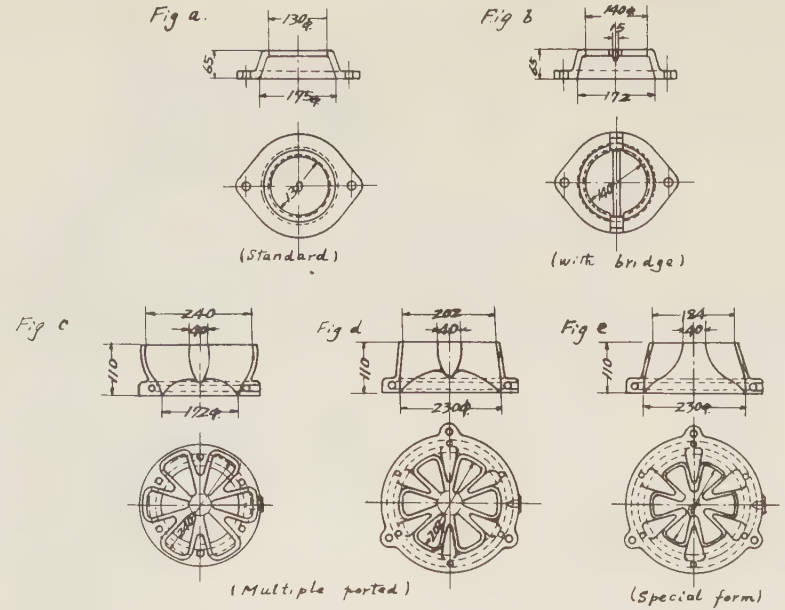
APPENDIX F/4. — Smokebox arrangement for test of « Star » nozzle K4Sc. — Pennsylvania Railroad.



APPENDIX F/5. — « Kylchap » double blast pipes and chimney. — London and North Eastern Railway.



APPENDIX F/0. — Types of blast pipe nozzle and single-jet double blast pipe arrangement. — Japanese Government Railways.



For equal cross-sectional areas of the blast nozzle, the standard form shewn in figure (*a*) is better than the form shewn in figure (*b*).

The multi-ported nozzles shewn in figures (*c*), (*d*) and (*e*) were not satisfactory as far as their effect on fuel was concerned.

Formula for single blast pipes:

$$d = c \sqrt{\frac{R}{1 + 0.1 \frac{R}{F}}}$$

where d = diam. of orifice (cm.).

R = grate area (m^2).

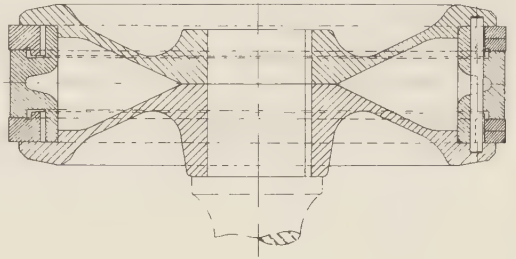
F = total sectional area of smoke tubes (m^2).

c = constant = 11.5 (Von Borries).

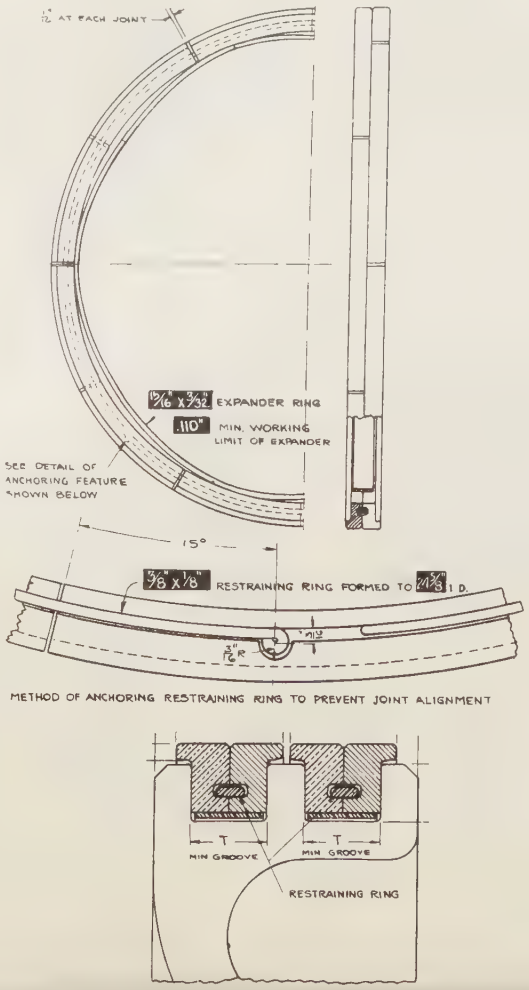
10.8 two-cylinder engines (Japanese Government Railways).

9.2 three-cylinder engines (Japanese Government Railways).

APPENDIX G/0. — Piston valve fitted with two narrow « L »-shaped rings. — Buenos Ayres Great Southern Railway.



APPENDIX G/1. — Special design of sectional piston rings. — Baltimore and Ohio Railroad.



APPENDIX G/2. — Class « C » steel for combined piston and rod (L. N. E. Specification No. 11). — London and North Eastern Railway.

Specification for steel forgings, class « C ». — The forgings to be in accordance with British Standard Specification No. 8, contained in Report No. 24, dated 1930, with additions shown below, and the maker must conform to all the conditions contained therein, and also to those set forth in the following clauses.

The forgings must be of British manufacture from steel of British manufacture throughout.

Branding. — All forgings to be stamped when hot with the maker's name, cast number, and the letters L. N. E.

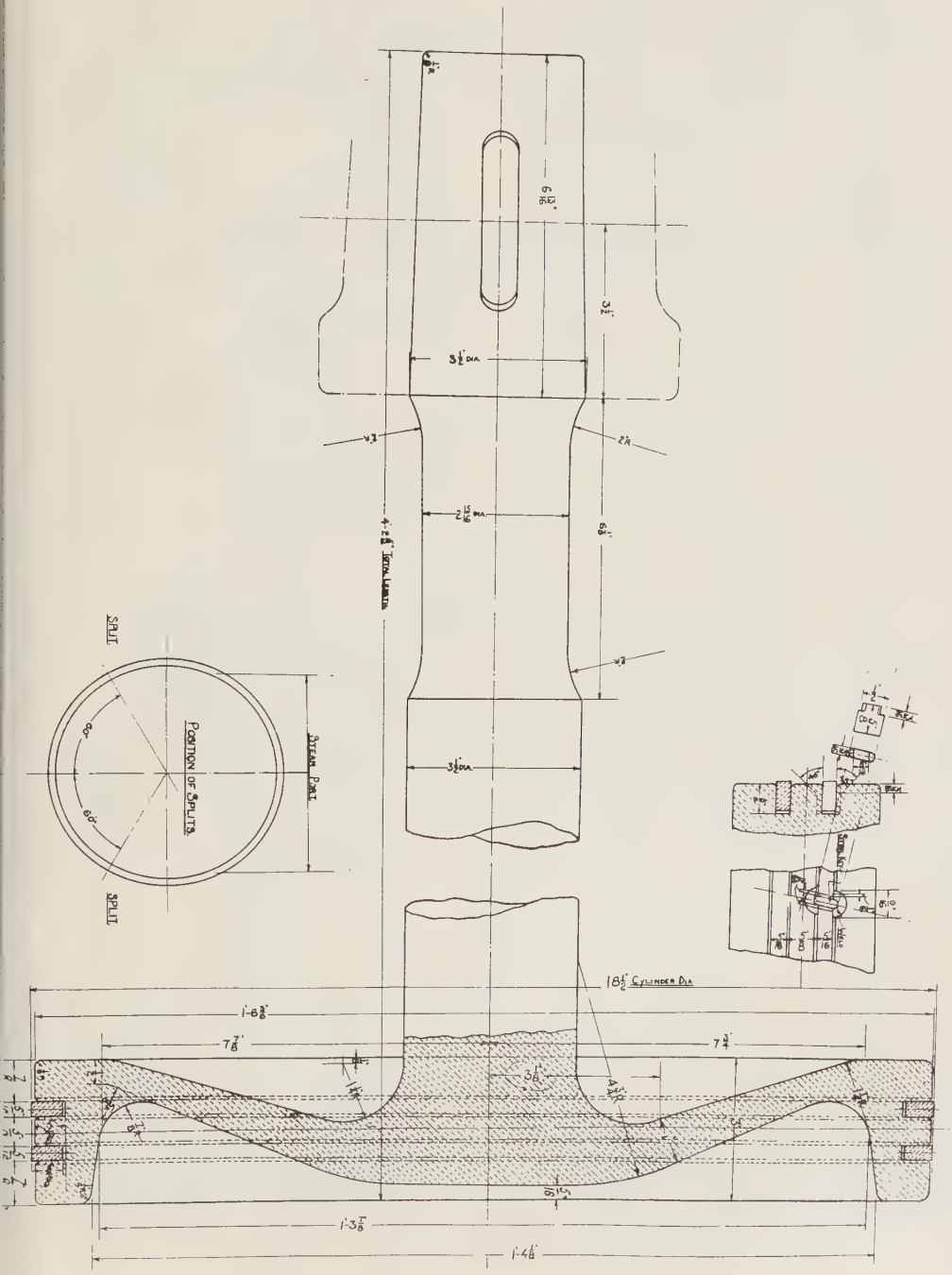
Classes of steel and tests.

Class	« C ».		
Description of forging	Special forgings without wearing surfaces.		
Process of manufacture	Acid open hearth, or electric.		
Maximum percentage of sulphur or of phosphorus	0.05.		
Tensile breaking strength in tons per sq. inch.	32 with	to	38 with
Minimum elongation	26 %		20 %

Tensile tests will be made on British standard test piece « D ».

Heat treatment. — All forgings in class « C » to be oil-treated.

APPENDIX G/3. — Combined piston rod and head for high-speed engines.
London and North Eastern Railway.



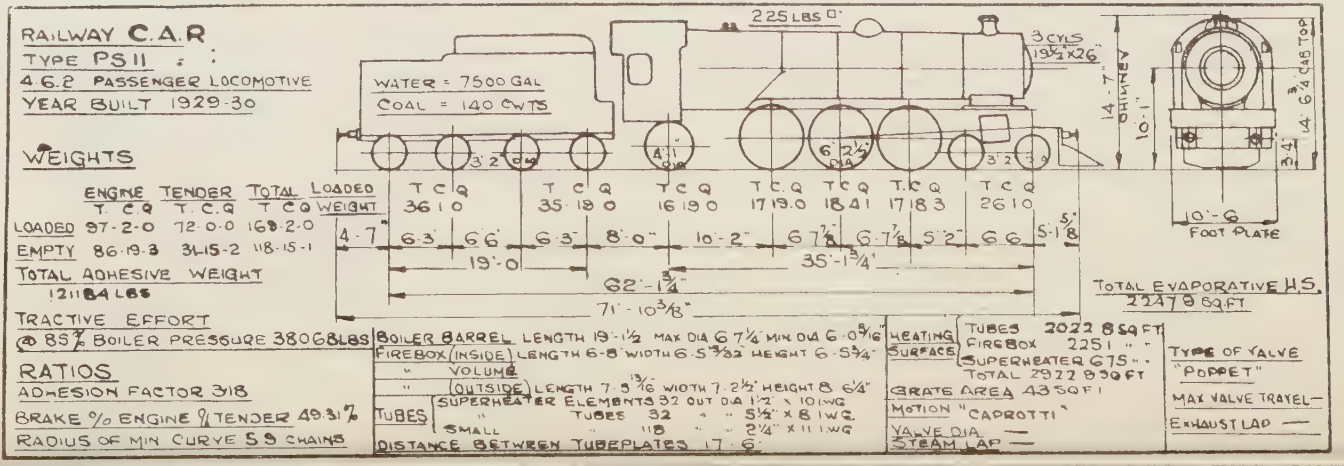
APPENDIX G 4. — Valve events: independent Walschaerts gear. Three-cylinder suburban 4-6-4 tank engines, Nos 2361-72. (Cylinders: 19" dia. × 26" stroke.) — Buenos Ayres and Pacific Railway.

Forward gear.

Cylinder	Cut-off	Lead		Valve opening		Cutt-off, %		Exhaust opens, %		Expansion, %		Exhaust port opening above full port		Exhaust closes, %	
		Front port	Back port	Front port	Back port	Front port	Back port	Front port	Back port	Front port	Back port	Front port	Back port	Front port	Back port
Outside	15 %	1/8"	1/8"	7/32"	1/4" B	15	17 1/2	68	66 1/2	53	49	7/32"	7/32"	66 1/2	68
Inside	15 %	1/8"	1/8"	3/16"	3/16" F	14 1/2	16 1/2	67 1/2	65	53	48 1/2	3/16"	3/16"	67 1/2	65
Outside	25 %	1/8"	1/8"	5/16"	11/32"	23 1/2	26	73 1/2	71 1/2	50	45 1/2	5/16"	5/16"	71 1/2	73 1/2
Inside	25 %	1/8"	1/8"	9/32"	5/16"	23 3/4	24 3/4	72 1/2	70	48 3/4	45 1/4	19/64"	19/64"	70	72
Outside	Full gear	1/8"	1/8"	1 3/8"	1 21/32"	70	70	91 1/2	90 1/2	21 1/2	20 1/2	1 1/2"	1 1/2"	90 1/2	91 1/2
Inside	Full gear	1/8"	1/8"	1 1/2"	1 9/16"	72 1/2	69	91	90	18 1/2	21	1 17/32"	1 17/32"	90	91

APPENDIX G/5. — P. S. 11 Pacific engine utilised for Caprotti valve gear trials.

Central Argentine Railway.



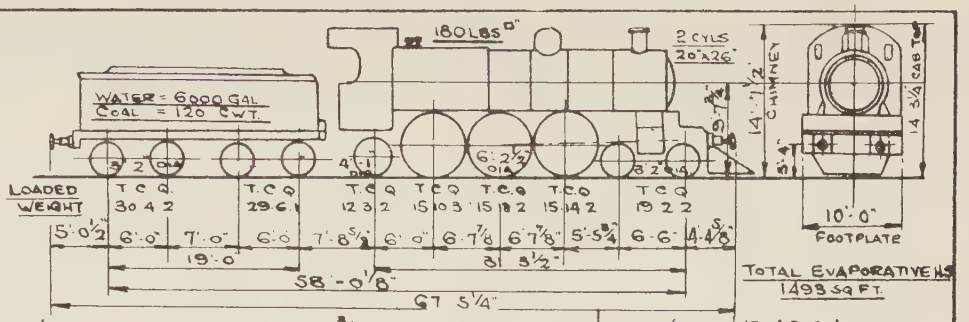
APPENDIX G/6. — P. S. 10 and P. S. 8 Pacific engines for comparison with P. S. 11 for fuel consumption.
Central Argentine Railway.

RAILWAY C.A.R.
TYPE P.S.10.
4 G 2 PASSENGER LOCOMOTIVE
YEAR BUILT. 1914

WEIGHTS

	ENGINE T.C.Q	TENDER T.C.Q	TOTAL T.C.Q
LOADED	78-9-3	59-10-3	138-0-2
EMPTY	71-2-2	27-13-2	98-16-0

TOTAL ADHESIVE WEIGHT
105700 LBS
TRACTIVE EFFORT
@ 85% BOILER PRESSURE 21359 LBS
RATIOS
ADHESION FACTOR 4.95
BRAKE % ENGINE & TENDER 46.41 %
RADIUS OF MIN CURVE 5 9 CHAINS



TOTAL EVAPORATIVE HS 1493 SQ FT.

BOILER BARREL LENGTH 13'-0¾" MAX DIA 5'-9"
FIREBOX (INSIDE) LENGTH 9'-1⅞" WIDTH 3'-6⅞" HEIGHT 6'-9⅝"
" VOLUME 200 C.F.
" (OUTSIDE) LENGTH 10'-0" WIDTH 4'-4¾" HEIGHT 9'-0 7/16"
TUBES — SUPERHEATER ELEMENTS 24 OUT DIA 1⅝" x 10 1 WG
SMALL TUBES 24 " " 5¼ x 8 I WG
" 121 " " 2" x 11 I WG
DISTANCE BETWEEN TUBEPLATES 13'-6⅞"

HEATING SURFACE — TUBES 1304 SQ FT; FIREBOX 189 30 FT; SUPERHEATER 355 -; TOTAL 1848 SQ FT
GRATE AREA 32.5 SQ FT.
MOTION "WALSCHAERT"
VALVE DIA 10"
STEAM LAP 1"

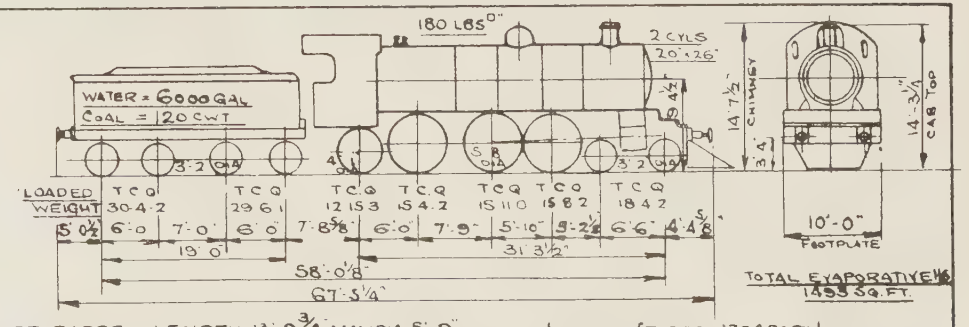
TYPE OF VALVE "PISTON"
MAX. VALVE TRAVEL 4 1/32"
EXHAUST LAP NIL.

RAILWAY C.A.R.
TYPE P.S.8
4 G 2 PASSENGER LOCOMOTIVE
YEAR BUILT 1914-16

WEIGHTS

	ENGINE T.C.Q	TENDER T.C.Q	TOTAL T.C.Q
LOADED	77-4-1	59-10-3	136-15-0
EMPTY	70-4-0	27-13-2	97-17-2

TOTAL ADHESIVE WEIGHT
103488 LBS
TRACTIVE EFFORT
@ 85% BOILER PRESSURE
23401 LBS
RATIOS
ADHESION FACTOR 4.42
BRAKE % ENGINE & TENDER
46.85 %
RADIUS OF MIN CURVE
5 9 CHAINS



TOTAL EVAPORATIVE HS 1455 SQ. FT.

BOILER BARREL LENGTH 13'-0¾" MAX DIA 5'-9"
FIREBOX (INSIDE) LENGTH 9'-11⅞" WIDTH 3'-6⅞" HEIGHT 6'-9⅝"
" VOLUME 200 C.F.
" (OUTSIDE) LENGTH 10'-0" WIDTH 4'-1¾" HEIGHT 9'-0 7/16"
TUBES — SUPERHEATER ELEMENTS 24 OUT DIA 1⅜" x 10 1 WG
SMALL TUBES 24 " " 5¼" x 8 1 W.G
" 121 " " 2" x 11 1 W.G
DISTANCE BETWEEN TUBEPLATES 13'-6⅞"

HEATING SURFACE — TUBES 1304 SQ FT; FIREBOX 189 SQ FT; SUPERHEATER 355 -; TOTAL 1849 SQ FT
GRATE AREA 32.5 SQ FT.
MOTION "WALSCHAERT"
VALVE DIA 10"
STEAM LAP 1"

TYPE OF VALVE "PISTON"
MAX VALVE TRAVEL 4 17/32"
EXHAUST LAP NIL

APPENDIX G/7. — Valve events, P.S. 11 engine, Caprotti gear. — Central Argentine Railway.

Notch.	Admission								Difference.	Exhaust				Difference.	Compression		Difference.
	Advance millim.		Admission Degrees		Opening millim.		Cut off, %			Opening, millim.		Release %					
	Front.	Back.	Front.	Back.	Front.	Back.	Front.	Back.		Front.	Back.	Front.	Back.		Front.	Back.	
Forward gear. — Left and right hand cylinders. — PS11. 1101-1120. Connecting rod : 10′ 5″.																	
65	5.5	5	—10	—10	16.5	16.5	67	62.5	4.5	25	25	87.5	85	2.5	71	75	4
60	5.5	5	—10	—10	16.5	16.5	63	58	5	25	25	87.5	85	2.5	71	75	4
50	5.5	5	—10	—10	16.5	16 5	53	47.5	5.5	25	25	87.5	85	2.5	71	75	4
40	5.5	5	—10	—10	16.5	16.5	42.5	37	5.5	25	25	87.5	85	2.5	71	75	4
30	5.5	5	—10	—10	16	16	32.5	27.5	5	25	25	87.5	85	2.5	71	75	4
20	8	8	—16	—16	14.5	14.5	22.5	18.5	4	25	25	87.5	85	2.5	71	75	4
15	10.5	10.5	—21	—21	13.5	13.5	17	14	3	25	25	87.5	85	2.5	71	75	4
10	13	13	—26	—26	13	13	11 5	9.5	2	25	25	87.5	85	2.5	71	75	4
Backward gear. — Left and right hand cylinders. — PS11. 1101-1120. Connecting rod : 10′ 5″.																	
65	6.5	6	—10	—10	16.5	16.5	67	62	5	25	25	85.5	82.5	3	70.5	75	4.5
60	6 5	6	—10	—10	16.5	16.5	63	57.5	5.5	25	25	85.5	82.5	3	70.5	75	4 5
50	6.5	6	—10	—10	16.5	16.5	53	47.5	5.5	25	25	85.5	82.5	3	70.5	75	4 5
40	6 5	6	—10	—10	16.5	16.5	42.5	37	5.5	25	25	85.5	82.5	3	70.5	75	4.5
30	6.5	6	—10	—10	16.5	16.5	33	28	5	25	25	85.5	82.5	3	70.5	75	4.5
20	7	7	—14	—14	14.5	14.5	21.5	18	3.5	25	25	85.5	82.5	3	70 5	75	4.5
15	9	9	—18	—18	13.5	13.5	16.5	14	2.5	25	25	85.5	82.5	3	70.5	75	4.5
10	12	12	—24	—24	13	13	11.5	9.5	2	25	25	85.5	82.5	3	70.5	75	4.5
Forward gear. — Mid cylinder. — PS11. 1101-1120. Connecting rod : 7′ 1″.																	
65	6.5	6.5	—10	—10	16.5	16.5	68.5	61.5	7	25	25	88	84	4	70	76	6
60	6.5	6.5	—10	—10	16.5	16.5	64.5	57.5	7	25	25	88	84	4	70	76	6
50	6.5	6.5	—10	—10	16.5	16.5	54	46	8	25	25	88	84	4	70	76	6
40	6.5	6.5	—10	—10	16.5	16.5	43.5	36	7 5	25	25	88	84	4	70	76	6
30	6.5	6.5	—10	—10	16.5	16.5	32.5	27	5.5	25	25	88	84	4	70	76	6
20	9	9	—18	—18	15.5	15.5	22.5	17.5	5	25	25	88	84	4	70	76	6
15	12	12	—24	24	15	15	17	13	4	25	25	88	84	4	70	76	6
10	14	14	—28	—24	14	14	11.5	9	2.5	25	25	88	84	4	70	76	6
Backward gear. — Mid cylinder. — PS11. 1101-1120. Connecting rod : 7′ 1″.																	
65	6.5	6	—10	—10	16.5	16.5	69	61.5	7.5	25	25	86	82	4	70	76	6
60	6.5	6	—10	—10	16.5	16.5	64	56.5	7.5	25	25	88	82	4	70	76	6
50	6.5	6	—10	—10	16.5	16.5	54	46	.8	25	25	86	82	4	70	76	6
40	6.5	6	—10	—10	16.5	16.5	43.5	36	7.5	25	25	86	82	4	70	76	6
30	6 5	6	—10	—10	16.5	16.5	33	26.5	6.5	25	25	86	82	4	70	76	6
20	7.5	7	—15	—14	15	15	22.5	17.5	5	25	25	86	82	4	70	76	6
15	8.5	8	—17	—16	13.5	13.5	17	12.5	4.5	25	25	86	82	4	70	76	6
10	12.5	12	—25	—24	13	13	11	8.5	2.5	25	25	86	82	4	70	76	6

APPENDIX G/8. - Valve events, new 4-6-2 and 4-8-0 engines. R. C. gear. — Delaware and Hudson Company.

4-6-2 type engines. Cylinders 22″ dia. × 32″ stroke.

Forward gear.

Cylinder.	Cut-off.	Lead.		Valve opening.		Cut-off, °/₀.		Exhaust opens, °/₀.		Expansion, °/₀.		Exhaust port opening above full port.		Exhaust closes, °/₀.	
		Front port.	Back port.	Front port.	Back port.	Front port.	Back port.	Front port.	Back port.	Front port.	Back port.	Front port.	Back port.	Front port.	Back port.
Outside	15 °/₀	0.225″	0 172″	0.275″	0.276″	14.843	15.722	94.922	92.187	80.078	76.464	...	...	60.254	63.086
Inside	15 °/₀	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Outside	25 °/₀	0.198″	0.146″	0.320″	0.326″	25.878	26.562	94.921	92.187	69.043	65.625	...	...	71.093	70.117
Inside	25 °/₀	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Outside	Full gear	00.18″	0.019″	0.707″	0.724″	84.570	86.718	94.922	93.554	10.351	6.836	...	...	95.508	92.880
Inside	Full gear	...	...	...	...	...	...	...	...	...	...	...	...	...	...

4-8 0 type engines. H.P. cylinders 20″ dia.×32″ stroke. I.P. cylinders 27 ½″ dia.×32″ stroke. L.P. cylinders 33″ dia.×32″ stroke.

Forward gear.

Cylinder.	Cut-off.	Lead.		Valve opening.		Cut-off, °/₀.		Exhaust opens, °/₀.		Expansion, °/₀.		Exhaust port opening above full port.		Exhaust closes, °/₀.	
		Front port.	Back port.	Front port.	Back port.	Front port.	Back port.	Front port.	Back port.	Front port.	Back port.	Front port.	Back port.	Front port.	Back port.
H.P. cylinder	43	0.141″	0.141″	0.750″	0.750″	43	49	80.00	83.00	37.00	34.00	...	...	91.50	89.50
I.P. cylinder	53	0.141″	0.141″	0.750″	0.750″	53	59	85.00	88.00	32.00	29.00	...	...	91.40	89.50
L.P. cylinder	43	0.141″	0.141″	0.875″	0.875″	43	37.5	88.00	85.00	45.00	47.50	...	...	89.50	91.40
H P. cylinder	50	0.141″	0.141″	1.000″	1.000″	50	56	83.00	86.00	33.00	30.00	...	...	91.50	89.50
I.P. cylinder	58	0.141″	0.141″	1.000″	1.000″	58	63.5	87.50	90.00	29.50	26.50	...	...	91.40	89.50
L.P. cylinder	43	0.141″	0.141″	1.000″	1.000″	43	37.5	90.00	87.50	47.00	50.00	...	...	89.50	91.40
H.P. cylinder	Full gear	0.031″	0.031″	1.00″	1.00″	87.5	90	99	99.2	11.5	9.2	...	...	99.00	98.80
I.P. cylinder	Full gear	0.031″	0.031″	1.00″	1.00″	87.5	90	99	99.2	11.5	9.2	...	...	99.00	98.80
L.P. cylinder	Full gear	0.031″	0.034″	1.063″	1.063″	90	87.5	99.2	99	9.2	11.5	...	...	98.80	99.00

APPENDIX G/9. Valve events, 2-6-0 two-cylinder (21" dia. × 26" stroke) engines, R. C. poppet valve gear. London Midland and Scottish Railway.

Forward gear.

Cylinder.	Cut-off.	Lead.		Valve opening.		Cut-off, °/₀.		Exhaust opens, °/₀.		Expansion, °/₀.		Exhaust port opening above full port.		Exhaust closes, °/₀.	
		Front port.	Back port.	Front port.	Back port.	Front port.	Back port.	Front port.	Back port.	Front port.	Back port.	Front port.	Back port.	Front port.	Back port.
Outside	15 °/₀	5/32"F	5/32"F	0.24"	0.24"	15	15	80	80	65	65	Nil	Nil	70	70
Inside	15 °/₀	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Outside	25 °/₀	5/32"F	5 32"F	0.37"	0.37"	25	25	80	80	55	55	Nil	Nil	70	70
Inside	25 °/₀	...	...	...	...	...	...	...	...	. .	...	...	...	...	...
Outside	Full gear	Nil	Nil	0.5"	0.5"	85	85	95	95	10	10	Nil	Nil	80	80
Inside	Full gear	...	...	...	...	...	...	...	...	...	...	...	...	...	...

APPENDIX G/10. — Valve events, 4-8-2, class 19 Co engine, R. C. gear. — South African Railways.

Steam valve.										Exhaust valve.						Max. valve opening.
Cut-off, °/₀.	Gear.	Max. valve opening.	Lead in inches.	Pre-admission, °.			Cut-off, °/₀.			Release, °/₀.			Compression, °/₀.			
				F. P.	B. P.	Diffs.	F. P.	B. P.	Diffs.	F. P.	B. P.	Diffs.	F. P.	B. P.	Diffs.	
85	Forward	3/4"	0"	0	0	0	86.5	82.9	3.6	95.6	94.2	1 4	11.4	8.8	2 6	7/8"
65	"	"	1/32"	0.1"	0.1"	0	68.7	62.2	6.5	91.2	88.6	2.6	16.4	12.8	3.6	"
50	"	"	1/8" b	0 6"	0.4"	0.2"	53.6	46.4	7.2	87 2	83.6	3.6	22.2	17.6	4.6	7/8"
40	"	0.6"	"	"	"	"	43.1	36.1	7.0	"	"	"	"	"	"	"
30	"	0.45"	3/16 '	1.3	0.9"	0.4	32.7	26.6	6.1	82.4	77.8	4.6	27.7	22.3	5.4	"
25	"	0.42"	1/4"	2.2	1.7	0.5	27 7	22.3	5.4	"	"	"	32.7	26.6	6.1	"
20	"	0.33"	7/32" b	"	"	"	22.2	17.6	4.6	"	"	"	"	"	"	"
15	"	0.28"	7 32" f	3.4	2.6	0.8	16.4	12.8	3 6	"	"	"	"	"	"	5/8"
Mid	Mid	...	. .	...	...	...	...	...	...	...	...	...	...	...	...	3/8"
30	Backward	0.45"	3/16"	1.3	0.9	0.4	32.7	26.6	6.1	87.2	83.6	3.6	22.2	17 6	4 6	5/8"
50	"	9/16"	1/16"	0.3	0.2	0.1	53.6	46.4	7.2	91 2	88.6	2.6	16.4	12.8	3.6	7/8"
85	"	11/16"	0"	0	0	0	86.5	82.9	3.6	95.6	94.2	1.4	11.4	8.8	2.6	"

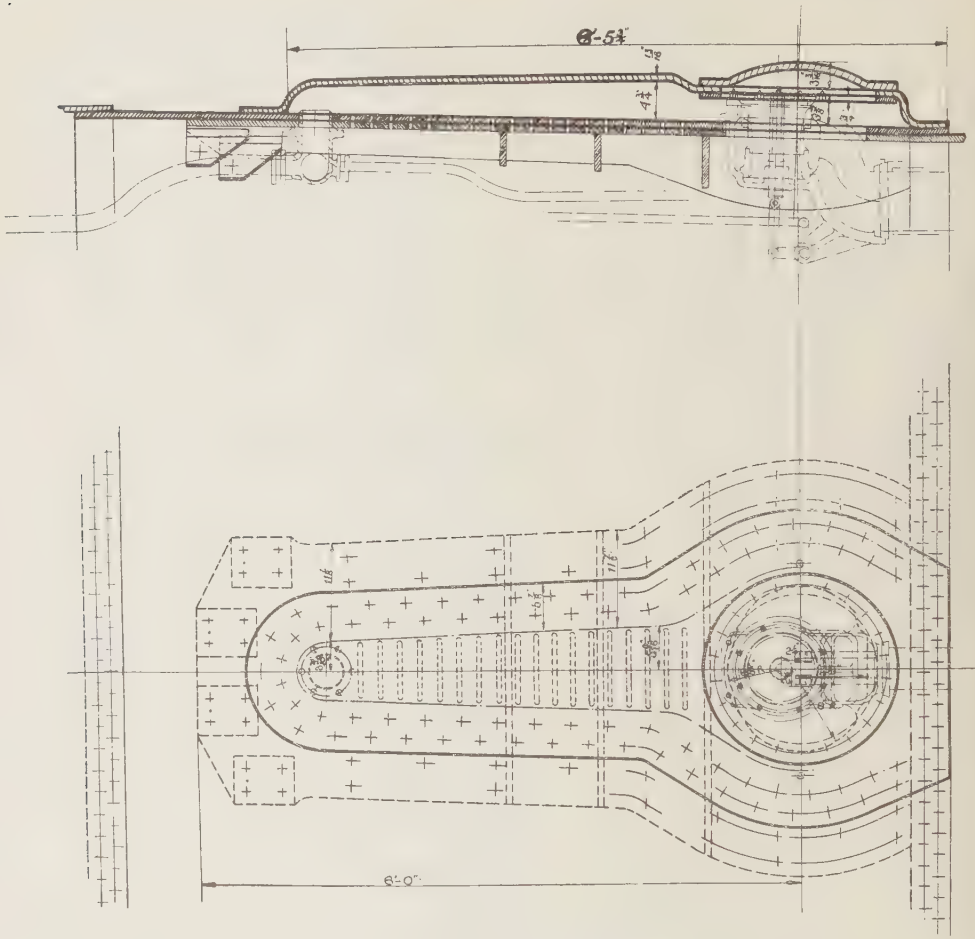
APPENDIX H/1. — Comparison of cross-sectional areas of elements with cross-sectional areas of steam pipe to header.

Baltimore and Ohio Railroad.

Class.	Throttle.		Steam pipe area.	Dry pipe area.	Header.		Units.		Smokebox steam pipes.		Cylinder neck. Total area.
	Valve area.	Box area.			Dry pipe end area.	Steam pipe end total area.	No.	Total area.	Total area (inside).	Total area (outside)	
	sq. in.	sq. in.	sq. in.	sq. in.	sq. in.	sq. in.		sq. in.	sq. in.	sq. in.	sq. in.
E-27x . .	43.35	44.915	33.183	33.183	33.183	47.516	25	28.45	47.516	..	56.548
E-27y .	43.35	44.915	33.183	33.183	33.183	47.516	27	32.13	47.516	...	56.548
E-27z . .	35.83	44.915	33.183	33.183	33.183	47.516	27	32.13	47.516	...	56.548
P-7 . . .	52.82	56.745	Combined with throttle box	62.785	56.745	76.970	40	45.52	76.970	...	88.358
P-9 . . .	52.16	60.78	63.617	62.785	56.745	76.970	40	47.60	76.970	...	88.358
P-9a . .	52.16	60.78	63.617	62.785	56.745	76.970	40	47.60	76.970	...	88.358
	43.35	44.915	50.265	63.617	56.745	76.970	40	47.60	76.970	...	76.970
Q-4 . . .	52.82	56.745	Combined with throttle box	56.745	56.745	76.970	40	45.52	76.970	...	76.970
S-1a . .	52.82	56.745		62.785	56.745	88.358	53	60.31	86.400	...	88.358
T-Ta . .	52.82	56.745		50.265	56.745	88.358	48	54.62	88.358	...	82.564
T-1 . . .	55.93	56.745	»	56.745	56.745	88.358	52	61.88	88.358	...	88.358
T-2 . . .	55.93	56.745	»	56.745	56.745	88.358	58	76.77 (Ø) 99.76 (+)	88.358	...	88.358
KK-1 . .	55.93	56.745	»	56.745	56.745	88.358	52	61.88	88.358	88.358	113.08
KK-2 . .	55.93	56.745	»	56.745	56.745	88.358	58	76.77 (Ø) 99.76 (+)	88.358	88.358	113.08
Q-1xa .	43.35	44.915	50.265	63.617	56.745	76.790	40	66.80 (*)	76.970	...	76.970
V-1 . . .	35.32	56.745	Combined with throttle box	56.745	56.745	76.970	40	66.80 (*)	76.970	...	76.970

(Ø) Unit tubes, 1-3/16".
(+) Header tubes, 1-3/4".
(*) Unit tubes, 1-3/4".

APPENDIX H/2. — Steam collector. — London and North Eastern Railway.



APPENDIX H/3. — Steam areas, P. 2, 2-8-2 engine, « Cock o' the North ».
London and North Eastern Railway.

Area through slots of steam collector		78.5 sq. in.
Minimum area from collector to dome		44.0 »
Area through regulator	Top valve	17.66 »
	Bottom valve	18.66 »
	Total area	36.32 »
Area through 7" dia. main steam pipe		38.485 »
» » superheater elements		32.77 »
» » one smokebox steam pipe		23.75 »
» » one steam valve, 12 % cut-off		14.07 »
» » » » 25 % »		22.7 »
» » » » 45 % »		35.9 »
» » » » 75 % »		48.5 »
» » port into cylinder		36.123 »
» » one exhaust valve 12 % cut-off		29.72 »
» » » » full over		56.34 »
» at base of blast pipe		117.81 »
» through blast nozzles		52.5 »
» » double chimney		490.7 »
Volume between regulator and steam valve		50.67 cu. ft.
Cylinder area		346.36 sq. in.
Piston load		76 199.508 lb.
Cylinder volume		9 005.396 cu. in.
Clearance volume — Outside cylinder — Head end		12.4 %
» » » » Crank »		11.78 %
» » Inside » Head		16.1 %
» » » » Crank »		15.8 %

THE PENNSYLVANIA RAILROAD

TYPE K4S

4-6-2 PASSENGER ENGINE

YEAR STREAMLINED 1936

WEIGHTS IN POUNDS	ENGINE	TENDER	TOTAL	LOADING WEIGHT
LOADED	338000	292000	630000	
EMPTY	303610	100020	403630	

TOTAL ADHESIVE WEIGHT 223000 LBS.

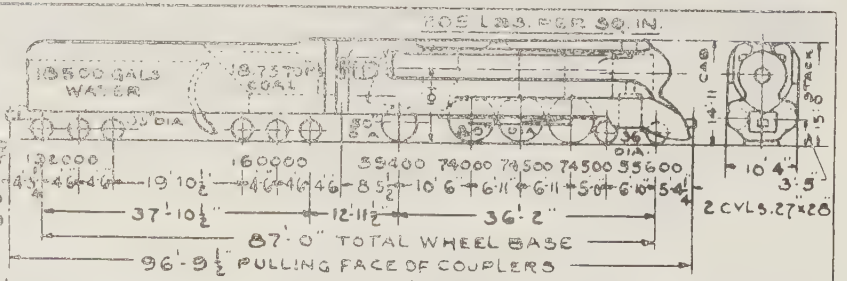
TRACTIVE EFFORT @ 85% BOILER PRESSURE 44460 LBS

RATIOS

ADHESION FACTOR 5.01

BRAKE % ENGINE & TENDER 67

RADIUS OF MIN. CURVE 275 FT



BOILER MAX. O.D. 7'-5" MIN O.D. 6'-6½"

FIRE BOX VOLUME 427 CU FT

TUBES: SUPRHTR 160 O.D. 1½" 149" THICK; " 40 O.D. 5½" .165" "; SMALL 236 O.D. 2¼" .120" "

DISTANCE BETWEEN TUBE PLATES 19'-0"

HEATING SURFACE: TUBES 3736 SQ FT; FIRE BOX 305 SQ FT; SUPERHTR 943 SQ FT; TOTAL 4984 SQ FT

TOTAL EVAPORATIVE 4041 SQ FT

GRATE AREA 69.89 SQ FT

TYPE OF MOTION WALSCHAERT

VALVE PISTON

VALVE DIA 12"

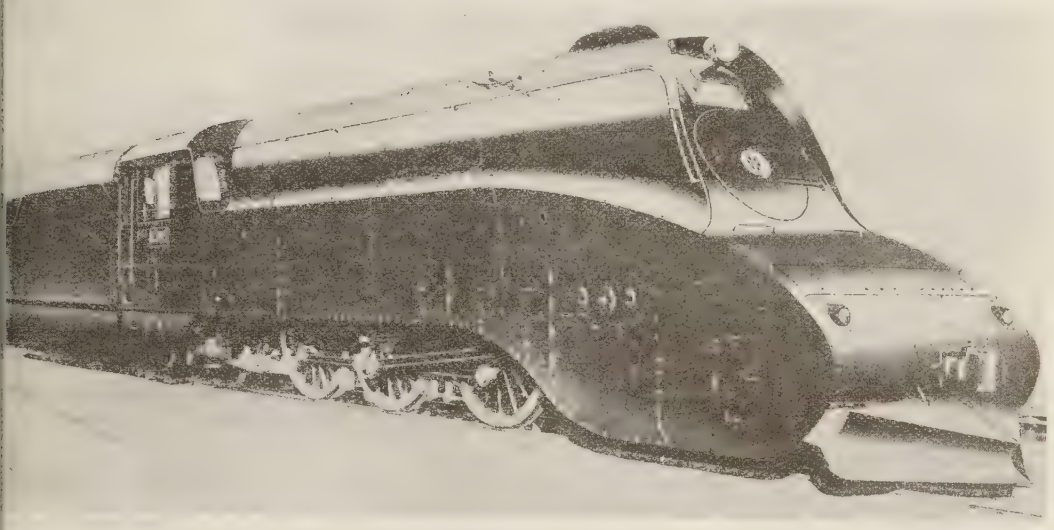
VALVE TRAVEL 7"

STEAM LAP 1 5/16" EXHAUST LAP - 3/8"

APPENDIX J/2. — **Streamlined locomotive, 4-6-2, A. 4, « Silver Link ».**
London and North Eastern Railway.

APPENDIX J/3. **Streamlined 4-6-2 locomotive, C. 55 type.** — Japanese Government Railways.

APPENDIX J/4. — 4-6-2 express passenger locomotive, C. 53 type, converted to streamlined. Japanese Government Railways.



APPENDIX K/1. — Special nickel-manganese steel for coupling and connecting rods. Analysis and heat treatment. — Delaware and Hudson Company.

Chemical characteristics.

Carbon	0.25 to 0.35
Manganese	0.60 to 1.00
Nickel	2.50 to 3.00
Phosphorus and sulphur, max.	0.045
Silicon	0.20 to 0.30

Physical characteristics.

Yield point, minimum	75 000 lb. per sq. in.
— desired	80 000 lb. per sq. in.
Tensile strength, minimum	100 000 lb. per sq. in.
Elongation, minimum	25 % in 2".
Reduction of area, minimum	50 %.
— desired	60 %.

Heat treatment.

The procedure to be followed in quenching and tempering shall consist in allowing the object, immediately after forging, to cool to a temperature below the critical range, under suitable conditions to prevent injury by too rapid cooling. They shall then be uniformly re-heated to the proper temperature to refine the grain (a group thus re-heated being known as a « quenching charge »), and quenched in some medium under substantially uniform conditions for each quenching charge. Finally they shall be uniformly re-heated to the proper temperature for tempering or « drawing back » (a group thus re-heated being known as a « tempering charge »), and allowed to cool uniformly.

APPENDIX K/2. — Manganese-molybdenum steel for coupling and connecting rods. — — London Midland and Scottish Railway.

Analysis:

Carbon	about 0.25
Manganese	1.6
Sulphur and phosphorus	0.04 max.
Molybdenum	about 0.25

Heat treatment:

Rods to be quenched in oil from about 850° C. and tempered at 650° C. — 670° C.

Physical tests:

Tensile	40 — 45 tons
Elongation	25 — 20 % min.
Yield points (% of tensile)	75
Izod	60 ft./lb. min.

APPENDIX K/3. — High-tensile steel for frames. London Midland and Scottish Railway.

Analysis:

Carbon	0.20 — 0.25
Silicon	0.1 — 0.2
Manganese	0.85 — 1.0
Sulphur and phosphorus	0.04 max.
Chromium	0.45 max.
Copper	0.30 — 0.50

Heat treatment. — Normalised.

Physical tests:

Tensile	35 - 40 tons
Elongation	20 % min.
Yield point	22 tons min.
Contraction	40 % min.

APPENDIX K/4. — Silico-manganese steel for springs. — London Midland and Scottish Railway.

Analysis:

Carbon	0.5 — 0.6
Silicon	1.8 2.0
Sulphur and phosphorus	0.04 max.
Manganese	0.7 — 1.0

The bars are rolled with a ribbed and grooved section, as shown in B. S. I. Specification No. 6B, Report 24, 1932.

Heat treatment:

Plates to be heated to approximately 850° C. and bent to the required camber and cooled below 600° C. Re-heated to 890° — 900° C. and quenched in linseed oil.

Tempered in a furnace standing at 800° C. for 5 minutes for 5/8" plates and 3 1/3 minutes for 1/2" plates, or until on trial with a hazel stick a heavy smoke and no sparks are produced, or until the temperature of the surface of the plate measured with a contact pyrometer is 400° C. — 425° C.

APPENDIX K/5. — Manganese-molybdenum steel for spring hangers (screwed adjustment type). London Midland and Scottish Railway.

Analysis:

Carbon	0.15 — 0.20
Silicon	0.25 max.
Manganese	1.5 — 1.7
Sulphur and phosphorus	0.04 max.
Nickel	0.3 — 0.5
Molybdenum	0.2 — 0.3

Heat treatment:

To be quenched in oil from about 850° C. and tempered at 650° — 670° C.

Physical tests:

Tensile	40 — 45 tons
Elongation	25 — 20 % min.
Yield point (% of tensile strength)	75
Izod	70 ft. lb. min.

APPENDIX K/6. — Nickel-chrome-molybdenum steel (L. N. E. R., specification No. 43) for coupling and connecting rods. — London and North Eastern Railway.

The forgings must be of British manufacture from the highest quality nickel-chrome-molybdenum steel of British manufacture throughout, produced in an acid open hearth or electric furnace. The steel shall contain from 0.3 to 0.5 per cent of molybdenum, and the maker shall supply an analysis of each cast.

Heat treatment. — All forgings must be machined prior to final heat treatment. The amount to be left on over finished size will be shown on the drawing accompanying the order.

Special care must be exercised during the process of heat treatment that the forgings are treated uniformly, and are not twisted or bent.

In the case of forgings machined to light cross section prior to heat treatment, the test block must be drilled or cut in such a manner that it will be similarly affected by the heat treatment.

All forgings must be heat treated with the test blocks attached.

Number of tests. — Test blocks will be left on one end of each forging, and from each forging two tensile, two Izod, and two bend test pieces will be taken after heat treatment.

Tensile tests. — Tensile tests will be made on British standard test piece C.

Tests from all forgings must show an ultimate tensile breaking strength of not less than 50 nor more than 57 tons per square inch, with a minimum elongation of 18 per cent. The yield point must not be less than 40 tons per square inch.

Izod tests. — The tests will be made on the British standard notched bar test piece of 10 mm. × 10 mm. cross section, or on the British standard notched round test pieces as shewn in figures 17 to 23 in B. S. I. Specification No. 131 — 1933.

The impact value must not be less than 35 foot-pounds.

Bend test. — A test piece 4 1/2 inches long, 3/4 inch wide, and 3/8 inch thick, must withstand being bent cold by pressure, or blows, round a bar or tool of 1 1/2 inches diameter till the sides are parallel without signs of fracture.

APPENDIX K/7. — « Vibrac » steel for coupling and connecting rods and valve gear.

Typical analysis. — Southern Railway.

Carbon	0.37 per cent.
Manganese	0.57 »
Nickel	2.48 »
Chromium	0.65 »
Molybdenum	0.60 »
Silicon	0.226 »

Sulphur and phosphorus below 0.035 per cent.

Specified mechanical tests :

Yield point	50 tons per sq. in.
Maximum stress	60 to 70 tons per sq. in.
Elongation	17.5 % on 2'' × 0.564''
Reduction of area	50 %
Izod notched bar value	40 foot-pounds.
Cold bend	3/4'' dia., 180° sides parallel.

Head treatment : Oil hardened and tempered.

APPENDIX K/8. — Nickel-chrome and carbon-vanadium steel for piston and connecting rods.

Japanese Government Railways.

Nickel-chrome steel. — Chemical analysis :

Nickel, %	Chrome, %	Phosphorus, %	Sulphur, %
3.0 to 4.0	0.25 to 0.75	less than 0.045	less than 0.045

Mechanical tests :

Ultimate strength	65-85 kgr./mm.²
Elastic limit	> 47 kgr./mm.²
Elongation	> 12 %

Heat treatment not specified.

APPENDIX K/8. *(concluded)*.

Carbon-vanadium steel. — Chemical analysis.

Carbon, %	Manganese, %	Phosphorus, %	Sulphur, %	Vanadium, %
0.45 — 0.55	0.70 — 0.95	less than 0.045	less than 0.050	less than 0.18

The amount of chrome as an impurity should be less than 0.25 %.

Mechanical tests:

Ultimate strength	> 63 kgr./mm.²
Elastic limit	> 42 kgr./mm.²
Elongation	> 20 %
Contraction	> 40 %
Heat treatment	Normalising in still air.

APPENDIX K/9. — Silico-manganese steel for springs. — Japanese Government Railways.

Ring springs (= buffing and drawgear springs).

Chemical analysis:

Carbon %	Silicon, %	Manganese, %	Chrome, %
0.57 — 0.71	1.02 — 1.06	0.96 — 1.08	0.34 — 0.49

Mechanical tests:

Ultimate strength	154 — 174 kgr./mm²
Elastic limit	130 — 139 »
Elongation	12 %
Contraction	32 %

Heat treatment not specified.

Bearing springs.

Chemical analysis:

Carbon, %	Silicon, %	Manganese, %	Phosphorus, %	Sulphur, %
0.60 — 0.70	1.50 — 1.80	0.70 — 0.90	Less than 0.045	Less than 0.045

Mechanical tests (not heat treated) :

Use.	Ultimate strength kgr./mm.²	Elongation, %.	
Laminated springs.	more than 85	more than 12	Test piece No. 1. JES.
Coil springs.	more than 85	more than 12	Test piece No. 2. JES.

Mechanical tests (heat treated) :

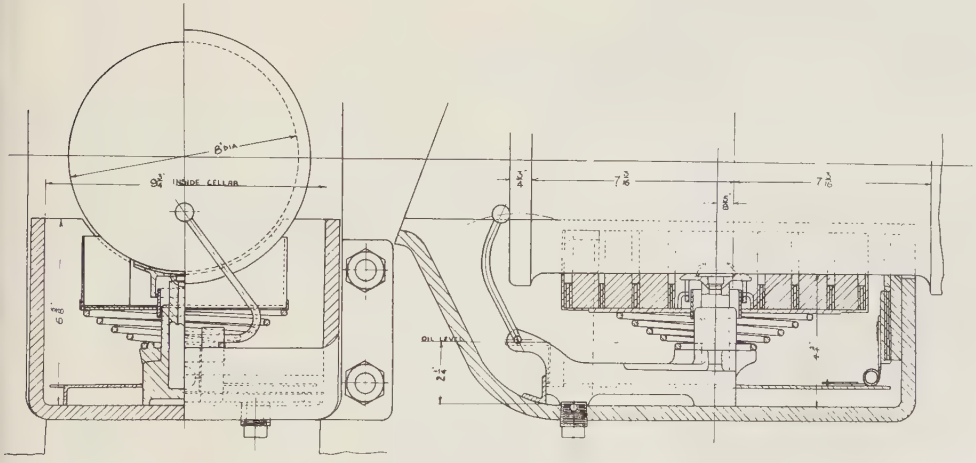
Test pieces Nos. 1 et 2.	Ultimate strength, kgr./mm².	Yield point, kgr./mm².	Elongation, %
	more than 140	more than 110	more than 5

Heat treatment:

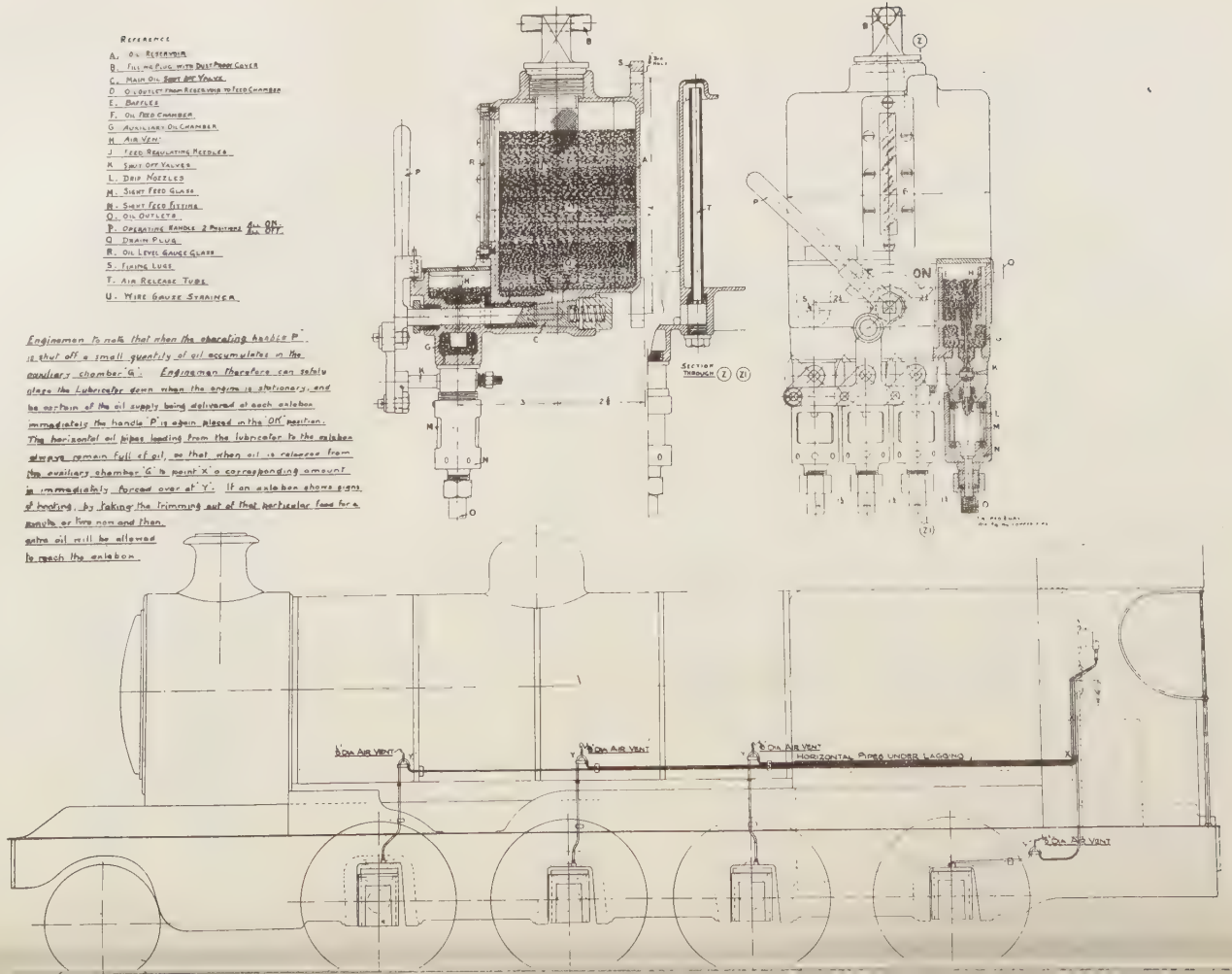
Quenching temperature . . . . . 820° C. — 850° C.
Annealing temperature . . . . . 470° C. — 520° C.

APPENDIX K/10. — « Hennessey » patent underfeed lubricator with pad and pump.

Reading Company.

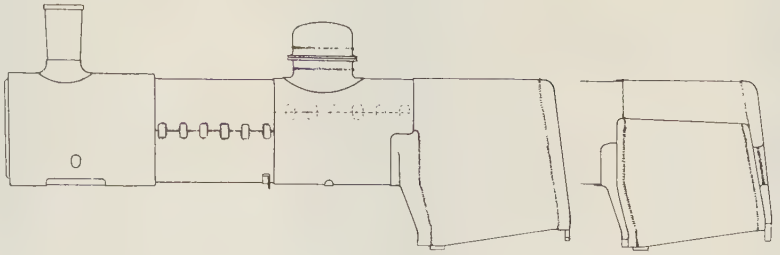


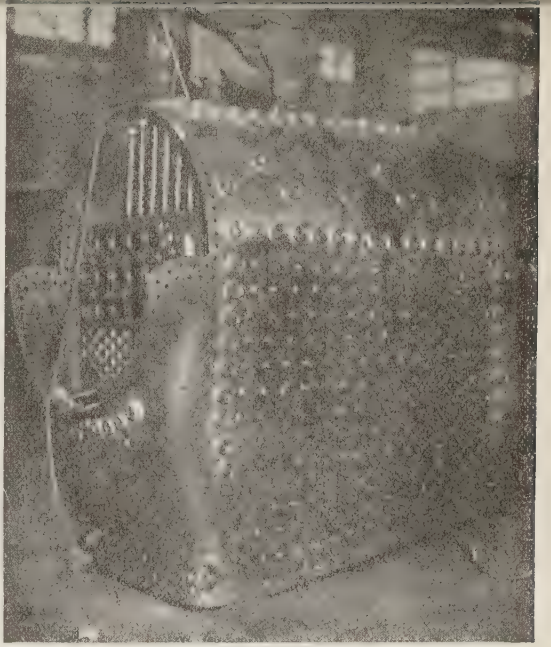
APPENDIX K/11. — « Fountain » type lubricator and pipe line.
London and North Eastern Railway.

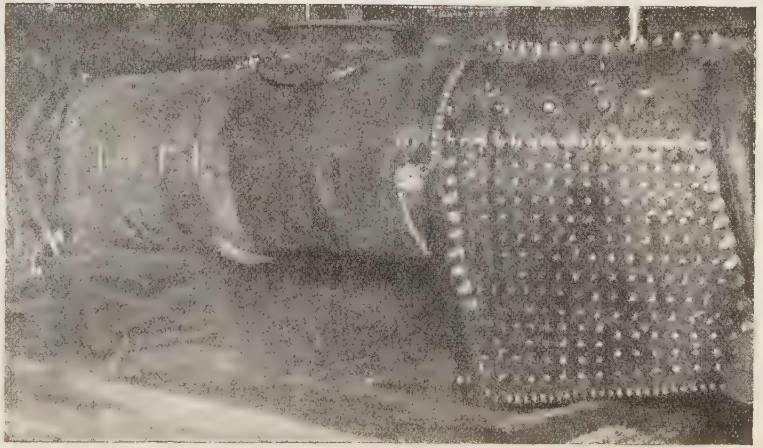

Reference
A. Oil Reservoir
B. Filling Plug with Dust Proof Cover
C. Main Oil Sight Feed Valve
D. Outlet from Reservoir to Feed Chamber
E. Baffles
F. Oil Feed Chamber
G. Auxiliary Oil Chamber
H. Air Vent
J. Feed Regulating Needles
K. Sight Off Valves
L. Drip Nozzles
M. Sight Feed Glass
N. Sight Feed Fitting
O. Oil Outlets
P. Operating Handle 2 Positions On Off
Q. Drain Plug
R. Oil Level Gauge Glass
S. Filling Lugs
T. Air Release Tube
U. Wire Gauze Strainer
Engineman to note that when the operating handle P is shut off a small quantity of oil accumulates in the auxiliary chamber G. Engineman therefore can safely stop the Lubricator down when the engine is stationary, and be certain of the oil supply being delivered at each anlaben immediately the handle P is again placed in the Off position. The horizontal oil pipes leading from the lubricator to the anlaben always remain full of oil, so that when oil is released from the auxiliary chamber G to point X a corresponding amount is immediately forced over at Y. If an anlaben shows signs of knocking, by taking the trimming out of that particular feed for a minute or two now and then, extra oil will be allowed to reach the anlaben
SECTION THROUGH Z Z1
ON
OFF
¼DIA AIR VENT
¼DIA AIR VENT
¼DIA AIR VENT
HORIZONTAL PIPES UNDER LAGGING
¼DIA AIR VENT

APPENDIX K/12. — Fabrication of boilers by electric welding.

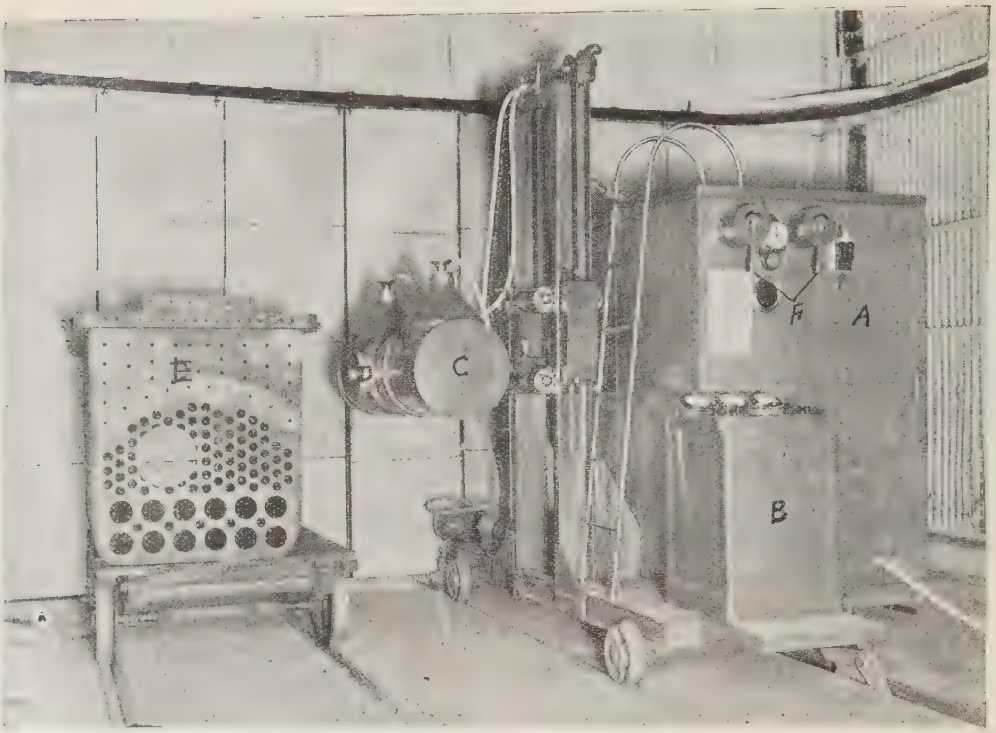
Japanese Government Railways.





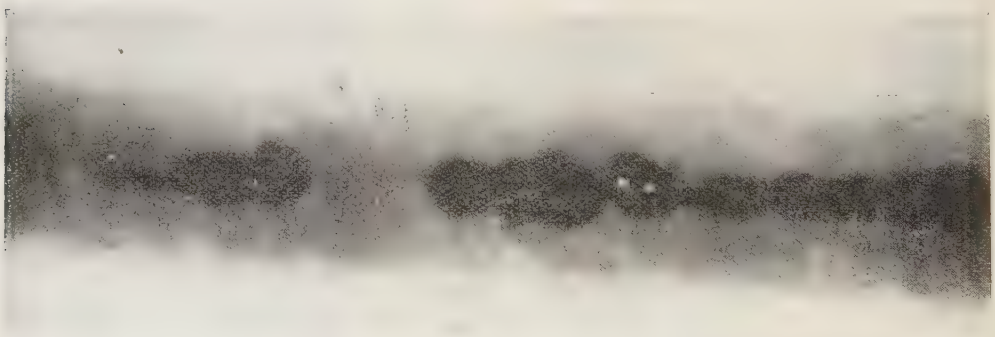


APPENDIX K/13. — X-ray examination of weld and particulars of machine.
Japanese Government Railways.

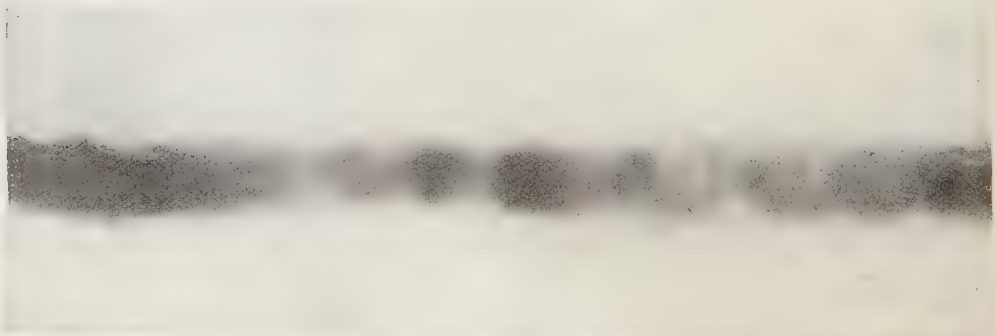


Roentgen apparatus:

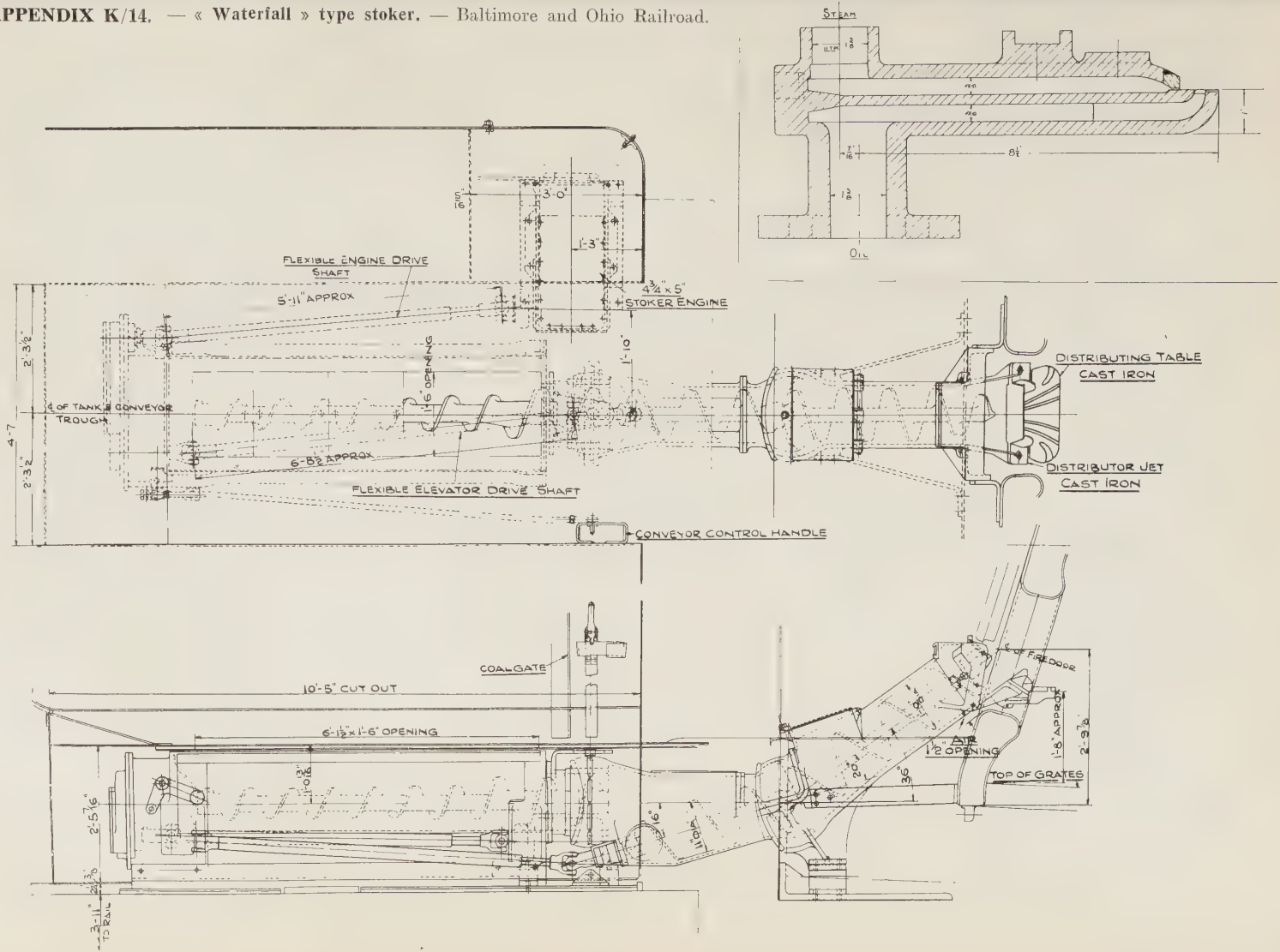
Manufacturer: Shimazu Seisakusho Ltd.
Electric source: 220 volt, A.C.
Maximum voltage of X-ray: 200 000 volts.
Maximum thickness or steel plate to be tested: 75 mm.
A Step-up transformer and rectifier chamber.
B Roentgen tube.
C Controller.
D Main switch.
E Switch for shifting.
F Switch for moving the Roentgen tube (B) up and down.
G X-ray radiating window.



X-ray of Takuma boiler, superheater header, 25 mm. thick. Single V butt weld.



APPENDIX K/14. — « **Waterfall** » **type stoker.** — Baltimore and Ohio Railroad.



PART TWO.

Tests of new types of steam locomotives constructed since 1930.

APPENDICES TO PART TWO.

Appendix number.	Detail.	Particulars.	Administration.	Chapter number.	Questio numbe
L/1	Diagram.	2-8-2 heavy goods engine.	Buenos Ayres and Pacific.	12	1 (a
L/2	Diagram.	0-8-0 shunting engine.	Buenos Ayres and Pacific.	12	1 (a
L/3	Diagram.	4-8-2 : 2-8-4 mixed traffic engine.	Buenos Ayres and Pacific.	12	1 (a
L/4	Diagram.	4-6-4 suburban tank engine.	Buenos Ayres and Pacific.	12	1 (a
L/5	Diagram.	4-6-4 engine (modified).	Buenos Ayres and Pacific.	12	1 (f
L/6	Diagram.	4-6-4 engine (modified to take tender).	Buenos Ayres and Pacific.	12	1 (f
L/7	Diagram.	T/1 4-8-2 passenger engine.	Baltimore and Ohio.	12	1 (a
L/8	Diagram.	T/2 4-8-2 passenger engine.	Baltimore and Ohio.	12	1 (a
L/9	Diagram.	KK/1 2-6-6-2 freight engine.	Baltimore and Ohio.	12	1 (a
L/10	Diagram.	KK/2 2-6-6-2 freight engine.	Baltimore and Ohio.	12	1 (a
L/11	Diagram.	4-6-2 passenger engine.	Delaware and Hudson.	12	1 (a
L/12	Diagram.	7P. 4-6-2 express passenger engine.	London, Midland and Scottish.	12	1 (a
L/13	Diagram.	6P. 4-6-0 express passenger engine.	London, Midland and Scottish.	12	1 (a
L/14	Diagram.	5XP. 4-6-4 express passenger engine.	London, Midland and Scottish.	12	1 (a
L/15	Diagram.	5P/5F. 4-6-0 mixed traffic engine.	London, Midland and Scottish.	12	1 (a
L/16	Diagram.	5P/4F. 2-6-0 mixed trafic engine.	London, Midland and Scottish.	12	1 (a
L/17	Diagram.	4P. 2-6-4 suburban passenger tank engine.	London, Midland and Scottish.	12	1 (a
L/18	Diagram.	3P. 2-6-2 mixed traffic tank engine.	London, Midland and Scottish.	12	1 (a
L/19	Diagram.	8F. 2-8-0 freight engine.	London, Midland and Scottish.	12	1 (a
L/20	Diagram.	Horizontal type regulator.	London, Midland and Scottish.	12	1 (c
L/21	Drawing.	Triangular section of wheel rim.	London, Midland and Scottish.	12	1 (c
L/22	Drawing.	Lubrication of little ends.	London, Midland and Scottish.	12	1 (c
L/23	Drawing.	A4. 4-6-2 streamlined express passenger engine.	London and North Eastern.	12	1 (a

pendix mber.	Detail.	Particulars.	Administration.	Chapter number.	Question number.
L/24	Diagrams.	P2. 2-8-2 express passenger engines.	London and North Eastern.	12	1 *(a)*
L/25	Diagram.	V2. 2-6-2 express passenger and goods engine.	London and North Eastern.	12	1 *(a)*
L/26	Diagram.	16E. 4-6-2 express passenger engine.	South African.	12	1 *(a)*
L/27	Diagram.	XP. 4-6-2 express passenger engine.	Great Indian Peninsula.	12	1 *(a)*
L/28	Diagram.	C.11. 2-6-4 passenger tank engine.	Japanese Government.	12	1 *(a)*
L/29	Diagram.	C.12. 2-6-2 passenger tank engine.	Japanese Government.	12	1 *(a)*
L/30	Diagrams.	C.55. 4-6-2 express passenger engine. C.55. 4-6-2 streamlined express passenger engine.	Japanese Government.	12	1 *(a)*
L/31	Diagram.	C.56. 2-6-0 heavy freight engine.	Japanese Government.	12	1 *(a)*
L/32	Diagram.	D.51. 2-8-2 branch passenger (tender) engine.	Japanese Government.	12	1 *(a)*
L/33	Table.	Results of dynamometer-car tests of new 2-6-6-2 and 4-8-2 engines.	Baltimore and Ohio.	12	2
L/34	Table.	Results of dynamometer-car tests of 5 new types of engines (express passenger and freight).	London, Midland and Scottish.	12	2
M/1	Diagram.	J.1. 4-4-4 express passenger engine.	Baltimore and Ohio.	13	1 *(a)*
M/2	Diagram.	V.1. 4-6-4 heavy passenger train engine.	Baltimore and Ohio.	13	1 *(a)*
M/3	Diagram.	V.2. 4-6-4 express passenger engine.	Baltimore and Ohio.	13	1 *(a)*
M/4	Diagram.	V.3. 4-6-4 heavy passenger train engine.	Baltimore and Ohio.	13	1 *(a)*
M/5	Diagram.	V.4. 4-6-4 heavy passenger train engine.	Baltimore and Ohio.	13	1 *(a)*
M/6	Diagram.	4-8-0 freight engine, « J. T. Loree ».	Delaware and Hudson.	13	1 *(a)*
M/7	Table.	Results obtained with test of V. 3 locomotive in ordinary train working.	Baltimore and Ohio.	13	2
N/1	Diagram.	Non-condensing turbine passenger engine.	London, Midland and Scottish.	14	1
N/2	Diagram.	General arrangement of turbine and reduction gearing.	London, Midland and Scottish.	14	1
N/3	Diagram.	Quill drive on leading axles.	London, Midland and Scottish.	14	1

CHAPTER TWELVE.

Reciprocating locomotives.

1. Types and descriptions.

Twenty-eight types of reciprocating locomotives (comprising thirteen wheel arrangements as shewn in the following table) have been constructed since 1930. A total of 1530 engines have been built, and the number of Administrations participating in this programme is eight. As the G. I. P. Railway locomotives, of the « Pacific » type, are still under construction, they have not been included in the figures given above.

Wheel arrangement	Tender or tank, etc.	Administration.	Number built.	Number under construction.	Diagram in appendix.
4-6-4	Tank.	Buenos Ayres and Pacific.	12	...	L/4
4-6-2 : 2-6-4	Garratt.	Nigerian (just delivered).	4	...	...
4-6-2	Tender.	Delaware and Hudson.	1	...	L/11
»	»	London Midland and Scottish.	(*)	(**)	...
»	»	London and North Eastern.	4	17	L/23
»	»	South African Railways.	6	...	L/26
»	»	Great Indian Peninsula (just designed).	...	2	L/27
»	»	Japanese Government : ordinary;	36	...	L/30
		streamlined.	21	...	
4-6-0	»	London, Midland and Scottish (three classes).	(*)	(**)	L/13, L/14 & L/15
2-6-4	Tank.	London Midland and Scottish.	(*)	(**)	L/17
»	»	Japanese Government.	115	...	L/28
2-6-2	»	London Midland and Scottish.	(*)	(**)	L/18
»	Tender.	London and North Eastern.	1	32	L/25
»	Tank.	Japanese Government.	127	...	L/29
2-6-2 : 6-2	Garratt.	Baltimore and Ohio (two classes).	One of each class.	...	L/9 & L/10
2-6-0	Tender.	London Midland and Scottish.	(*)	(**)	L/16
»	Tender.	Japanese Government.	48	...	L/31
4-8-2 : 2-8-4	Garratt.	Buenos Ayres and Pacific.	4	...	L/3
4-8-2	Tender.	Baltimore and Ohio (two classes).	One of each class.	...	L/7 & L/8
2-8-2	»	Buenos Ayres and Pacific.	8	...	L/1
»	»	London and North Eastern.	4	2	L/24
2-8-2	»	Japanese Government.	51	...	L/32
2-8-0	»	London, Midland and Scottish.	(*)	(**)	L/19
0-8-0		Buenos Ayres and Pacific.	15	...	L/2

(*) Total for all classes. London Midland and Scottish, 1 069 (built).

(**) Total for all classes, London Midland and Scottish, 537 (under construction to end of 1935).

The Buenos Ayres and Pacific's new types comprise heavy goods, 2-8-2; *Garratt,* 4-8-2 : 2-8-4; shunting, 0-8-0; and three-cylinder 4-8-4 suburban tank engines. The heavy goods are limited cut-off engines at 65 % and are fitted with steam operated coal pushers on the tender. The *Garratts* also have limited cut-off to 60 %, auxiliary ports to 75 % and one engine only is equipped with a coal pusher. The shunting engines have no special features except that the water tanks are of all-welded construction. The suburban tank engines' special feature is the independent Walschaerts valve gear, embodying the Stephenson-Molyneux modified drive to the centre valve. The boilers of all four types are of orthodox design, excepting that one Garratt engine employs a thermic syphon. No departure from standard has been made with regard to materials used. The 2-8-2 goods engines were designed for working fast and heavy freight trains over severe gradients, and the 4-6-4 for suburban passenger work. This type was later modified (see Appendix L/5) to handle fruit trains on a lighter track; water capacity of the engine tanks was reduced and the coal increased, a 50-ton travelling water tank being coupled as a separate unit. The engine was further modified by fitting an articulated tender and removing the side tanks and bunker (see Appendix L/6).

The Baltimore and Ohio Railroad's four types, 4-8-2 passenger and 2-6 : 6-2 freight engines are, so far as their mechanical parts are concerned, orthodox, but one type of each wheel arrangement is equipped with a water tube firebox. The pressure of these engines is 250 lb./sq. in. and 2 % nickel steel boiler plates are used. The passenger engines were designed for through traffic over mountainous districts and the freight engines for fast services and to obviate double heading.

The Delaware and Hudson Company's new Pacific of 325 lb./sq. in. pressure and R. C. gear could equally be dealt with in the chapter on *High pressure locomotives,* but its entire orthodoxy, coupled with the advance in design which it represents, has led to its various interesting features being dealt with throughout Part One, and the only reason for its inclusion in the present chapter is that it may be included in the total of conventional types constructed since 1930.

The L. M. S. Railway has the largest number of new types, as well as by far the greatest total of new engines built. There are three new types of express passenger (4-6-2 and 4-6-0), two of mixed traffic (4-6-0 and 2-6-0) and one each of freight (2-8-0), passenger tank (2-6-4) and mixed traffic tank (2-6-2) engines.

The design of the locomotives and boilers is, in every case, orthodox. 2 % nickel steel is used in the boilers of the « Princess Royal » class and « Monel » metal for the throat plate stays. Horizontal type regulators are fitted (see Appendix L/20). Triangular section of wheel rim centres (Appendix L/21) and a substantial oil reservoir for the small end (Appendix L/22) are also provided.

Apart from the « Princess Royal », and the « Royal Scot » with tapered boiler, which are used on the heavy express passenger trains to the North, and the 2-8-0 freight engines designed for hauling heavy mineral traffic, the tender engines have been built to function as general utility locomotives within certain defined loadings. The 2-6-4 passenger tank engine was designed to effect rapid acceleration from starting, and fast running with suburban trains.

The three new types on the L. N. E. R. are express passenger engines. The A.4 streamlined *Pacific* for high-speed trains, the P.2, 2-8-2, for heavy gradient service in Scotland, and the V. 2, 2-6-2,

for fast goods in addition to normal express work.

All the engines are of orthodox design for three-cylinder locomotives and have Walschaerts/Gresley gear, with the exception of one P. 2. type, which is fitted with R. C. gear. Boilers are of conventional designs embodying combustion chambers and steam collectors, the A. 4 engines and one P. 2, Part 2, having specially long combustion chambers. No departure from standard practice of the Company has been made as regards materials.

The new *Pacific* engine of the South African Railways, designed for express passenger work over fairly flat country, has 6′ 0″ diameter driving wheels, R. C. gear, and a large grate. The boiler is of usual design, but nickel steel is employed for the plates, and the firebox is of steel, the pressure being 210 lb./sq. in.

The Great Indian Peninsula Railway's new *Pacific* engine is of conventional design embodying Caprotti valve gear, roller bearings to all wheels and in one case to the large ends and side rod crank pins. The balancing of only 33 1/3 % of the reciprocating weights is an interesting development. Thermic syphons, multiple regulators and flexible stays in certain areas, together with the welded fabrication of the steel firebox, are the only special items concerning the boiler. Special metals have been adopted for stays (« Longstrand » steel) and crank pins (case-hardened Krupp steel), whilst « Ferrobestos » has been used for the brakegear bushes and bogie centre liners. The engines have been designed to meet anticipated higher speeds of express passenger trains.

The Japanese Government Railways' six new types comprise two *Pacifics*, one of which is streamlined, two passenger tanks, a 2-8-2 heavy freight engine, and a 2-6-0 tender engine for use on branch lines where axle load is limited. Apart from the streamlined casing of the *Pacific* engine, the locomotives follow orthodox design, but the boilers have been fabricated by welding. Special materials have not been used in the construction.

2. Tests.

Three Railways only have reported on tests carried out on the line. The results obtained by the Baltimore and Ohio and the London Midland and Scottish are given as Appendices L/33 and L/34 respectively, and those of the South African Railways' *Pacific* engine, together with an extract from the L.M.S. tests for an engine of similar wheel arrangement, are compared below :

Particulars.	*London Midland and Scottish.*	*South African.*
Wheel arrangement	4-6-2	4-6-2
Diam. coupled wheels	6′ 6″	6′ 0″
Number of cylinders.	4	2
Diam. of cylinders :		
outside (inches)	16 1/4	24
inside (inches)	16 1/4	...
Stroke (inches)	28	28
Valves	Piston.	Poppet.
Valve gear	Walschaerts.	R.C.
Boiler pressure (lb./sq. in.)	250	210
Heating surface :		
Total evap. (sq. ft.)	2 314	2 917
Superheat (sq. ft.)	623	580
Total (sq. ft.)	2 937	3 497
Tractive effort at 85 % boiler pressure (lb.).	40 300	35 280 **at 75 %.**

The test figures obtained are as under:

Particulars.	*London Midland and Scottish.*	*South African.*
Speeds attained (m.p.h.) :		
maximum	82	...
average	53	55
Weight of train (tons)	575	500
Drawbar pull (tons) :		
maximum	...	16.1
at 10 m.p.h.	11.5	...
at 60 m.p.h.	4.9	...
Drawbar horse-power, maximum sustained	1 647	1 700
Consumption :		
Fuel, lb./D.B.H.P.	2.92	...
Fuel, lb./I.H.P.	...	3
Water, lb./D.B.H.P.	25.6	...
Water, lb./I.H.P.	...	19
Evaporation, lb./lb.	8.76	6.33
Steam temperature (°F.) :		
at header	...	650 (max.)
at steam chest	580	...
at exhaust	...	...
Steam pressure (lb./sq. in.) :		
in boiler	250	210
in steam chest	245	204
in exhaust	6	...

3, 4 and 5. **Comparisons with previous types of engines of comparable power, and conclusions.**

Generally speaking, the engines are of such recent design as to preclude an exact comparison being drawn under the headings of control, reliability and accessibility, but in the cases of the Baltimore and Ohio, and the South African Railways, the comparison is stated to be favourable.

The first cost per ton is difficult to assess, in view of the absence of uniform statistics. The L. M. S. shew an 8 % increase, equated to 1935 cost of manufacture, whilst the South African Railways state that the costs compare favourably with those of other large engines. The costs per ton, F. O. B. given by the Buenos Ayres and Pacific are : 2-8-2, £ 70/10/0 d.; 0-8-0, £ 79/10/0 d.; 4-8-2 : 2-8-4, £ 100/0/0 d.; 4-6-4, £ 66/0/0 d.; and the Baltimore and Ohio quote 0.261 dollars as the price per pound (£ 121/16/0 d. per ton) of their engines, which they consider high on account of the few engines built and pattern prices included.

Maintenance is shewn to compare favourably in the cases of the Buenos Ayres and Pacific, Baltimore and Ohio, and Japanese Government Railways, but the other Railways state that insufficient experience has been obtained to reply, although the L. M. S. anticipate less cost.

The general conclusions expressed are that the locomotives have fully met requirements.

CHAPTER THIRTEEN.

High-pressure locomotives.

1. Types and descriptions.

Six new types of high-pressure locomotives have been designed and constructed since 1930, but only one engine in each class has been built.

The Baltimore and Ohio Railroad is responsible for five of the types, which have a working pressure of 350 lb./sq. in. (see Appendices M/1 to M/5). The remaining engine belongs to the Delaware and Hudson Company, and has a working pressure of 500 lb./sq. in. (see Appendix M/6).

The Baltimore and Ohio engines are equipped with trailer boosters and « Emerson » water-tube fireboxes, in which circulator plates have been incorporated. 2 % nickel steel has been used for the boiler plates and the stay bolts are of iron.

The 4-4-4 (J. 1) and the 4-6-4 (V. 2) types have been designed for working light fast passenger trains, the J. 1 for the « Abraham Lincoln », Chicago to St. Louis, and the V. 2 for the « Royal Blue », Washington to New York. The remaining engines (4-6-4) are destined for heavy passenger services and to eliminate double heading.

The Delaware and Hudson engine has only just been built. It is a triple expansion 4-8-0 engine, fitted with R. C. poppet valve gear, with a minimum cut-off at 43 %. The firebox is of the four-drum water-tube type, similar to the « Horatio Allen », a recent previous engine of this Company. An experimental superheater is fitted in which the elements extend into the fire space. Silico-manganese steel is used for the boiler shell, and the stay bolts are of « Ulster » special iron.

2. Tests.

Tests of the Baltimore and Ohio V. 3 (4-6-4) only have been made, and no comparison with other comparable engines is therefore possible. No outstanding results were obtained on the test run (for particulars see Appendix M/7).

3, 4 and 5. Comparison with previous types of engines of comparable power.

The Baltimore and Ohio state that these latest engines compare favourably as regards control, and that no difference in reliability and accessibility exist, compared with similar powered engines. The average cost per ton of tare weight is £ 84. Maintenance is considered comparable and an increased life of stays and plates of the firebox legs is realised with circulator plates. The availability and mileage between general repairs of these engines compared with engines of lower boiler pressure have suffered no reduction, also no increased frequency of periodical boiler examination has been found necessary. The locomotives have fully met requirements, and it is anticipated that further engines of the different classes will be built in the future.

No information under these headings has been given in respect to the Delaware and Hudson high-pressure locomotive.

* * *

CHAPTER FOURTEEN.

Turbine locomotives.

The London, Midland and Scottish Railway is the only Administration to reply to this question.

1. a) **Outline diagram of the turbine locomotives and their accessory equipment constructed since 1930 and the number built.**

See engine diagram, and diagram of details, Appendices N/1, and N/2, and N/3. One engine built.

b) **General descriptions and characteristics of the turbines (foregear and backgear), their control from the cab, and the relative power of each. Particulars of the idle gear and of the control of the cab if single turbine is provided for forward and reverse motion.**

The forward turbine of 2 000-h.p. is fitted on the left-hand side of the engine main frames, and is of a multiple stage type having a high efficiency over a wide range of engine speed.

Six steam nozzles are provided, the number required to haul the train is controlled by suitable gear from the cab.

The reverse turbine is fitted on the right-hand side of the main frames, and is of less power than the forward turbine. Three nozzles are provided and controlled from the engine cab.

c) **Particulars of the main transmission and of the drive to the coupled wheels.**

The forward turbine shaft is directly coupled to the transmission gear, which consists of treble reduction gear of the double helical type, and a thoroughly flexible drive is provided by means of a hollow quill shaft fitted with a pair of flexible diaphragm couplings. To permit of the necessary relative movement between the engine frame and the driving axle, the final drive from the slow speed gear wheel to the crank arms formed on the main driving axle is a very flexible one, being coupled by means of a series of floating links. Leaf springs between the rim and the boss of this slow speed gear wheel prevent transmission of shocks to the high speed gear.

The reverse turbine is of the impulse type with an additional single reduction gear. When the reverse turbine is put into gear, the driven wheel shaft is moved laterally and the pinion formed on the end of the shaft engages with a similar internal cut gear on the main turbine shaft.

The whole of the transmission gear is completely enclosed in a fabricated gear case suspended from three points of support on the engine frame, and provision is made for restricting transverse movement between the frames.

The whole of the drive is taken through the transmission gear to the leading coupled wheel, and the three sets of driving wheels are coupled together by the usual form of coupling rod. The revolving mass of the coupling rods and crank pins, as affecting each separate pair of wheels, is balanced in that pair of wheels.

d) **Type, location and particulars of the condenser and water cooling equipment together with the vacuum obtained.**

A condenser is not fitted.

e) **Particulars of the exhaust for non-condensing turbines and of the arrangement for creating the draught in the smokebox with condensing turbines.**

The exhaust is taken through frame stay and exhaust passages provided between the main frames under the smokebox, and a double type of blast pipe and chimney provided.

A variable blast pipe is provided which consists of a central cone dart, raised and lowered automatically above the blast pipe orifice as the number of steam nozzles for the turbine is increased or decreased. A special type of intermediate petticoat to the blast pipe cap is also used.

f) I) *Particulars of the oil cooling arrangements and of the oil temperatures before and after the operation.*

At the rear end of the transmission gear case and at the lowest portion is

provided a submerged gear pump. This delivers oil at 25 lb./sq. in. through internal channels to the gear case sprays, and to the bearings of the turbines and gears.

A second pump is carried on the main frames under the footplate and is steam driven, its function being to augment the supply from the gear pump and also to provide the necessary means for passing the oil through an oil cooler situated between the frames at the front of the locomotive just above the buffer beam.

The steam driven pump can be maintained in motion when the engine is standing, so that the oil circulation through the cooler is maintained until the locomotive is again set in motion when the gear pump automatically comes into operation.

The oil temperatures before passing into, and after leaving the cooler, are not available.

II) *Brief specification of the oil used (in the gear case) with the de-emulsification figure.*

The specification of the oil used in the gear case is as follows :

Specific gravity at	60° F. .	0.900
Pour test		15° F.
Open flash point.		395° F.
Redwood viscosity at	70° F.	690
	100° F.	250
	140° F.	93
	200° F.	74
De-emulsification.		2 minutes.

g) **Details of the boiler, and if of unusual design, brief description of the special features.**

The boiler is of orthodox design, with 3′ 6 1/4″ long combustion chamber.

h) **The maximum designed steam temperature at the turbine.**

The estimated steam temperature for the turbine is about 700-750° F.

I) *Special materials used in the construction of the turbine locomotive, and the considerations which influenced their selection.*

The boiler is of 2 % nickel steel (see Appendix A/2 for specification), and the frame of special high tensile steel (see Appendix K/3 for specification).

2. **Nature of the tests carried out, with particulars of speeds attained, weight of train, drawbar pull, drawbar horsepowers, fuel and water comsumption, evaporation, steam temperatures at header, turbine steam chest and exhaust; and vacuum in condenser (if fitted). In addition some indication of the power absorbed by the various auxiliaries.**

Tests on the turbine engine have not yet been carried out.

3. **Comparison of the turbine locomotive with a comparable locomotive of orthodox design and equal power as regards**

a) **Ease of manipulation and control.**

Steam control to turbine is by means of I) regulator in cab, and II) control gear box for turbine nozzles. The nozzles (six in number) are opened progressively. Forward and reverse gear are controlled by locking gear situated in the cab. The locking gear prevents steam being applied until the gear is positioned. The forward or reverse gear can only be engaged when the engine is at rest.

When the engine is in reverse drive, the forward turbine which is permanently connected to the transmission gear rotates in the reverse direction but, as the steam is shut off at the nozzles for the forward turbine, no power is developed.

b) **Reliability.**

Sufficient experience has not been obtained to give information with regard to reliability.

c) **Accessibility.**

Special care was exercised in design. Roller bearings were fitted to coupled axles as a precaution against hot boxes which, on leading coupled axle, would necessitate dismantling transmission gear and quill drive attachment to remove wheels.

d) **First cost per ton of tare weight.**

Since only one locomotive has been built, any figures given would not be truly representative.

e) **Fuel and water consumption.**

Not yet available.

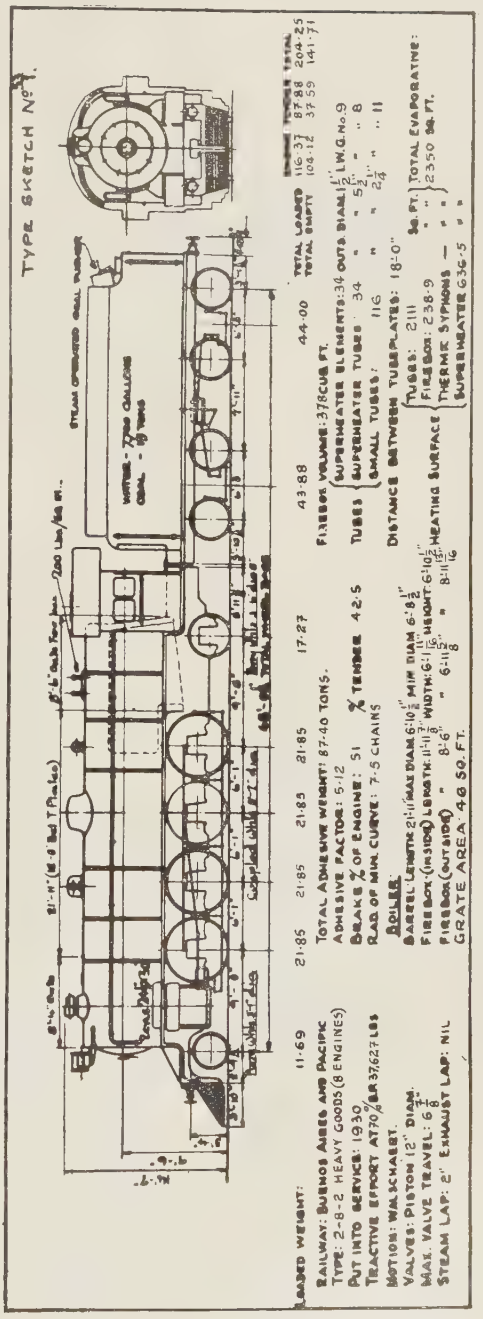
4. Comparison of maintenance costs with those of steam locomotives of ordinary types and comparable power.

Insufficient experience has been obtained for a comparison to be made.

5. General conclusions with special reference to the future of the turbine locomotives.

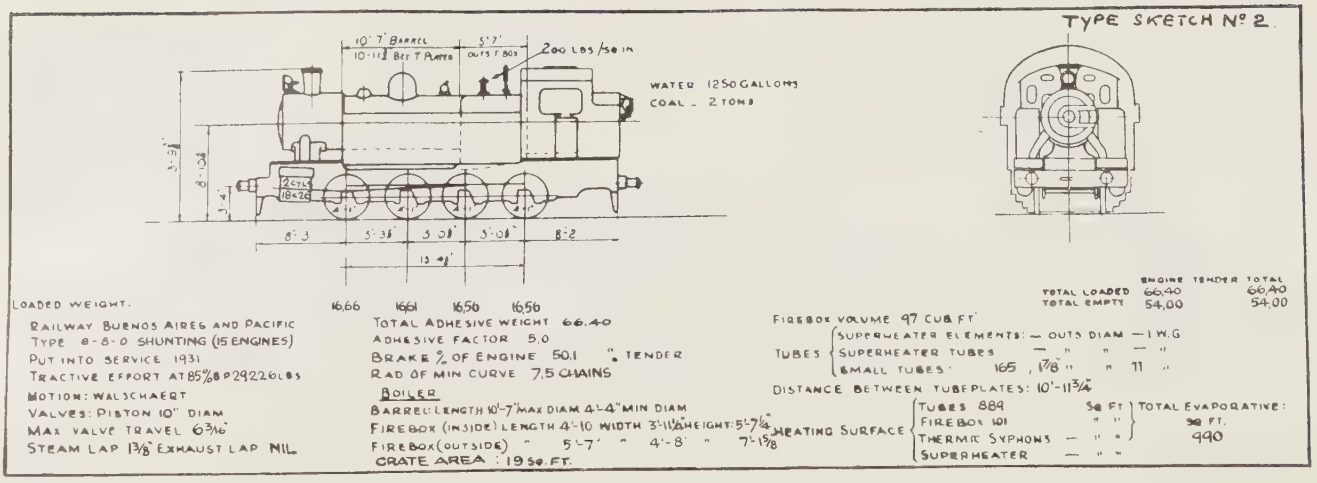
Due to the short length of time this engine has been in service, sufficient information is not available with regard to the future development of the turbine locomotive for railway operating.

* * *

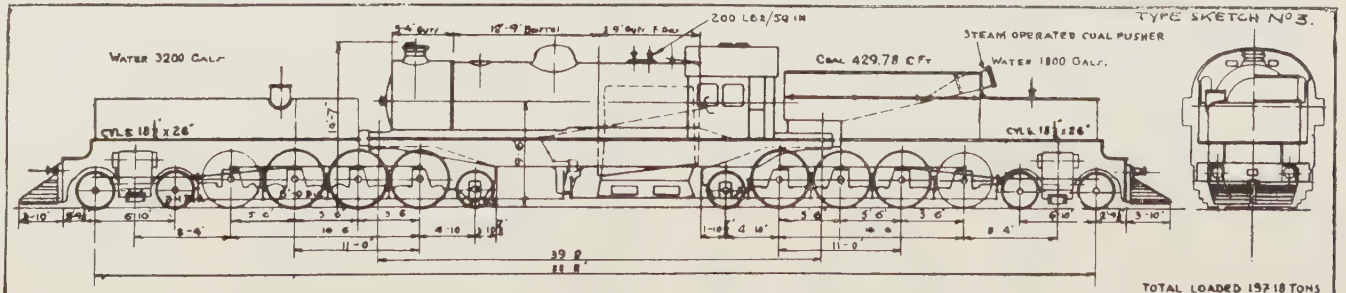

TYPE SKETCH No 4.
LOADED WEIGHT: 11-69 21-85 21-85 21-85 17-27 43-88 44-00
RAILWAY: BUENOS AIRES AND PACIFIC
TYPE: 2-8-2 HEAVY GOODS (8 ENGINES)
PUT INTO SERVICE: 1930
TRACTIVE EFFORT AT 70% BP 37627 LBS
MOTION: WALSCHAERT.
VALVES: PISTON 12" DIAM.
MAX. VALVE TRAVEL: 6 7/8"
STEAM LAP: 2" EXHAUST LAP: NIL
TOTAL ADHESIVE WEIGHT: 87-40 TONS.
ADHESIVE FACTOR: 5-12
BRAKE % OF ENGINE: 51 % TENDER 42-5
RAD OF MIN CURVE: 7-5 CHAINS
BOILER:
BARREL: LENGTH 21-1/16" MAX DIAM 6-10 5/8" MIN DIAM 6-8 1/2"
FIRE BOX (INSIDE) LENGTH: 11-11 7/8" WIDTH: 6-1 11/16" HEIGHT 6-10 1/2"
FIREBOX (OUTSIDE) " 8-6 3/8" " 6-11 5/8" " 8-11 15/16"
GRATE AREA: 46 SQ.FT.
FIREBOX VOLUME: 378 CUB FT.
SUPERHEATER ELEMENTS: 34 OUTS DIAM 1 1/4" I.W.G. No 9
SUPERHEATER TUBES: 34 " " 5 1/2" " " 8
SMALL TUBES: 116 " " 2 1/4" " " 11
DISTANCE BETWEEN TUBEPLATES: 18-0"
TUBES: 211
FIREBOX: 238-9
THERMIC SYPHONS — " "
SUPERHEATER 636-5 " "
TOTAL LOADED 116-37 87.88 204-25
TOTAL EMPTY 104-12 37.59 141-71
SQ. FT. TOTAL EVAPORATIVE: " " 2350 SQ. FT.
HEATING SURFACE

APPENDIX L/1. — 2-8-2 heavy goods engine. — Buenos Ayres and Pacific Railway.

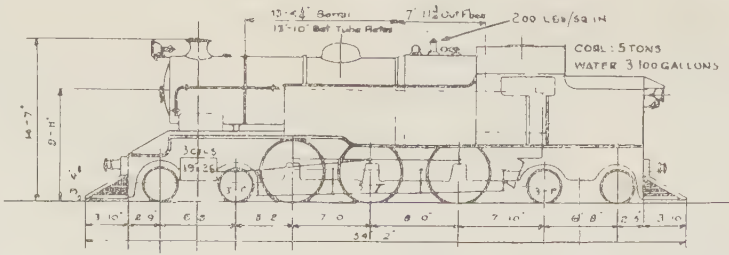
APPENDIX L/2. — 0-8-0 shunting engine. — Buenos Ayres and Pacific Railway.

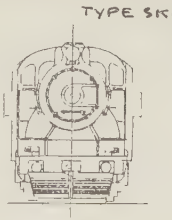

TYPE SKETCH Nº 2.
10'-7" BARREL
10-11/2 BET T PLATES
5'-7"
OUTS F BOX
200 LBS/SQ IN
WATER 1250 GALLONS
COAL - 2 TONS
2 CYLS 18×26
8'-3
5'-3 1/2"
5'-0 1/2"
5'-0 1/2"
8'-2
13'-4 1/2"
TOTAL LOADED 66,40 66,40
TOTAL EMPTY 54,00 54,00
LOADED WEIGHT.
16.66 16.61 16.56 16.56
RAILWAY BUENOS AIRES AND PACIFIC
TYPE 0-8-0 SHUNTING (15 ENGINES)
PUT INTO SERVICE 1931
TRACTIVE EFFORT AT 85% BP 29226 LBS
MOTION: WALSCHAERT
VALVES: PISTON 10" DIAM
MAX VALVE TRAVEL 6 3/16"
STEAM LAP 1 3/8" EXHAUST LAP NIL
TOTAL ADHESIVE WEIGHT 66.40
ADHESIVE FACTOR 5.0
BRAKE % OF ENGINE 50.1 % TENDER
RAD OF MIN CURVE 7.5 CHAINS
BOILER
BARREL: LENGTH 10'-7" MAX DIAM 4'-4" MIN DIAM
FIREBOX (INSIDE) LENGTH 4'-10 WIDTH 3'-11 1/4" HEIGHT 5'-7 1/4"
FIREBOX (OUTSIDE) " 5'-7" " 4'-8" " 7'-1 3/8"
GRATE AREA : 19 SQ. FT.
FIREBOX VOLUME 97 CUB FT
TUBES { SUPERHEATER ELEMENTS: — OUTS DIAM — I.W.G
SUPERHEATER TUBES — " " — "
SMALL TUBES: 165 , 1 7/8" " " 11 "
DISTANCE BETWEEN TUBEPLATES: 10'-11 3/4"
HEATING SURFACE { TUBES 884 Sq FT
FIREBOX 101 " "
THERMIC SYPHONS — " "
SUPERHEATER — " "
TOTAL EVAPORATIVE: 98 FT. 990

APPENDIX L/3. — 4-8-2 : 2-8-4 mixed traffic engine. — Buenos Ayres and Pacific Railway.


TYPE SKETCH Nº 3.
200 LBS/SQ IN
STEAM OPERATED COAL PUSHER
WATER 3200 GALS
COAL 429.78 C FT
WATER 1800 GALS.
CYLS 18 1/2" x 26"
CYLS 18 1/2" x 26"
39 0
22 8
TOTAL LOADED 197.18 TONS
TOTAL EMPTY 153.66 TONS
LOADED WEIGHT: 27.95 14.23 14.23 14.23 14.23 18.72 13.72 14.23 14.23 14.23 14.23 27.95 TONS
RAILWAY: BUENOS AIRES AND PACIFIC
TYPE: 4-8-2 — 2-8-4 MIXED TRAFFIC
PUT INTO SERVICE YEAR 1930 (1 ENGINE)
TRACTIVE EFFORT AT 70% BP 41 525 LBS
MOTION: WALSCHAERT
VALVES PISTON. 10 DIAM.
MAX. VALVE TRAVEL 5 3/4"
STEAM LAP 1 3/4" EXHAUST LAP NIL
TOTAL ADHESIVE WEIGHT: 113.84 TONS
ADHESIVE FACTOR: 6.07
BRAKE % OF ENGINE: 50.6 %
RAD OF MIN CURVE: 7.5 CHAINS (150 METRES)
BOILER
BARREL: LENGTH: 12'-9" MAX DIAM 6'-6" MIN DIAM 6'-4 7/16"
FIREBOX (INSIDE) LENGTH 7'-10 3/8" WIDTH 6'-4 1/4" HEIGHT 7'-9"
FIREBOX (OUTSIDE) " 8'-9" " 7'-1 1/2" "
FIREBOX VOLUME 337 CUB FT
TUBES { SUPERHEATER ELEMENTS: 40. OUTS DIAM 1 5/8" I.W.G. No 8 (M.L.S.)
SUPERHEATER TUBES: 40. " " 5 1/2" " " 8
SMALL TUBES: 228 " " 1 3/4" " " 10
DISTANCE BETWEEN TUBEPLATES: 19'-2 5/8"
HEATING SURFACE { TUBES 2156 Sq FT.
FIREBOX 223 "
THERMIC SYPHONS 60 "
SUPERHEATER 510 "
TOTAL EVAPORATIVE: 2439 SQ.FT.

APPENDIX L/4. — 4-6-4 suburban tank engine. — Buenos Ayres and Pacific Railway.





						ENGINE	TENDER	TOTAL
LOADED WEIGHT:	30,07	21,54	21,84	21,59	35,31	TOTAL LOADED	130,4	
						TOTAL EMPTY:	102,1	

RAILWAY. BUENOS AIRES AND PACIFIC
TYPE: 4-6-4 (SUBURBAN TANK)
PUT INTO SERVICE 1930 (12 ENGINES)
TRACTIVE EFFORT AT 85% BP 36,600 LBS
MOTION: WALSCHAERT
VALVES: PISTON 10" DIAM.
MAX. VALVE TRAVEL 6⅞"
STEAM LAP. 1¾" EXHAUST LAP. NIL

TOTAL ADHESIVE WEIGHT: 65 TONS
ADHESIVE FACTOR: 4.02
BRAKE % OF ENGINE 61,5 % TENDER —
RAD. OF MIN. CURVE 7,5 CHAINS

BOILER
BARREL LENGTH 13'-4½" MAX DIAM. 5'-9" MIN DIAM 5'-7⅝"
FIREBOX (INSIDE) LENGTH 7'-1⅜" WIDTH 5'-0⅜" HEIGHT 6'-8¼"
FIREBOX (OUTSIDE) " 8'-0" " 6'-2" " 8'-11 9/16"
GRATE AREA 27 SQ. FT

FIREBOX VOLUME 204 CUB. FT

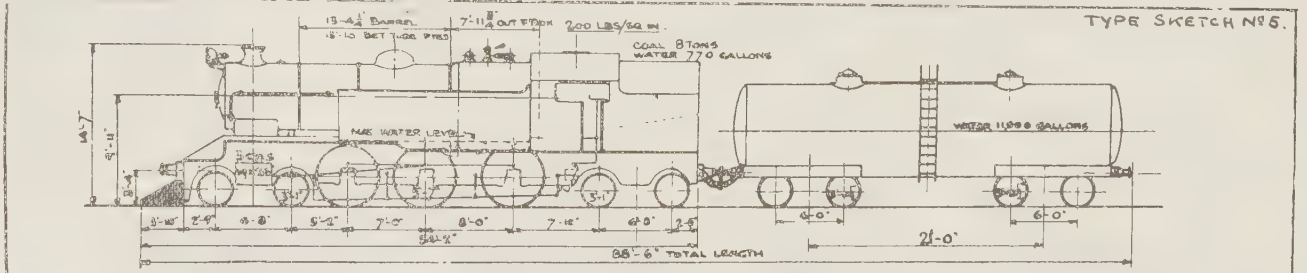
TUBES	SUPERHEATER ELEMENTS:	28	OUTS. DIAM.	1 3/16"	W.G. 9
	SUPERHEATER TUBES	28	" "	5¼"	" 8
	SMALL TUBES:	148	" "	1⅞"	" 11

DISTANCE BETWEEN TUBEPLATES 13'-10"

HEATING SURFACE	TUBES:	1538	Sq. FT.
	FIREBOX:	162	" "
	THERMIC SYPHONS	—	" "
	SUPERHEATER	354	" "

TOTAL EVAPORATIVE: 1,700 SQ. FT.

APPENDIX L/5. — 4-6-4 engine (modified). — Buenos Ayres and Pacific Railway.



TYPE SKETCH No 5.

							ENGINE	TENDER	TOTAL
LOADED WEIGHT:	28·0	20·3	20·4	20·3	32·0	38·0	TOTAL LOADED	121·0	76·0	197·0
							TOTAL EMPTY	102·0	26·0	128·0

RAILWAY: BUENOS AIRES AND PACIFIC
TYPE: 4-6-4 TANK FOR GOODS SERVICE
PUT INTO SERVICE: 1930 (12 ENGINES)
TRACTIVE EFFORT AT 85% BP 35,600 LBS
MOTION: WALSCHAERT
VALVES: PISTON 10" DIAM.
MAX. VALVE TRAVEL 6⅞"
STEAM LAP 1¾" EXHAUST LAP. NIL

TOTAL ADHESIVE WEIGHT: 61 TONS.
ADHESIVE FACTOR: 3·83
BRAKE % OF ENGINE 70·6 % TENDER 35·5 (LOADED)
RAD OF MIN. CURVE: 7·5 CHAINS

BOILER
BARREL LENGTH 13'-4½" MAX DIAM. 5'-9" MIN. DIAM. 5'-7⅝"
FIREBOX (INSIDE) LENGTH 7'-1 3/16" WIDTH 5'-0⅜" HEIGHT 6'-8¼"
FIREBOX (OUTSIDE) " 8'-0" " 6'-2" " 8'-11 9/16"
GRATE AREA 27 SQ. FT

FIREBOX VOLUME 204 CUB. FT.

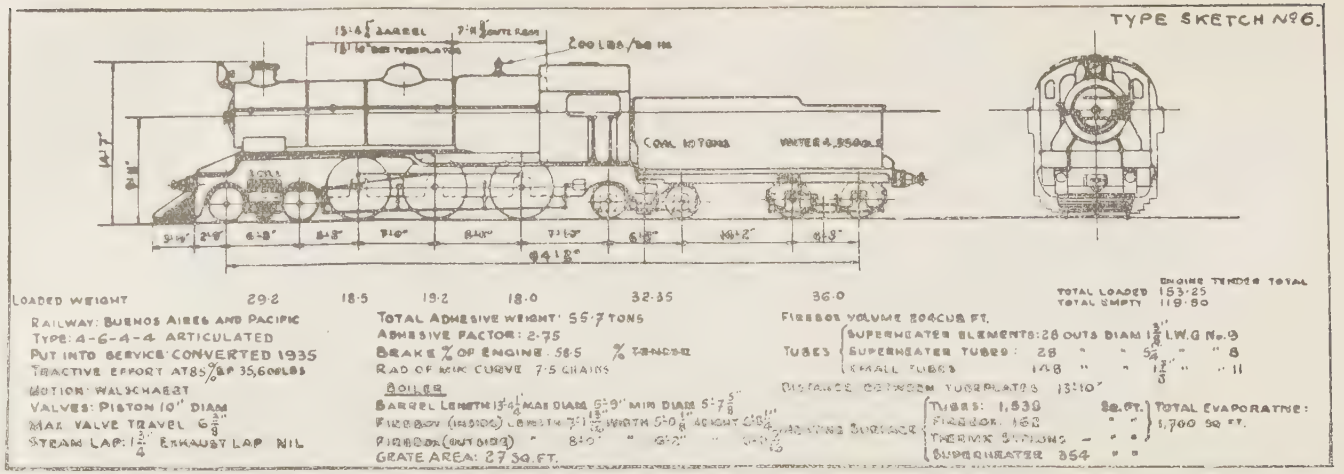
TUBES	SUPERHEATER ELEMENTS:	28	OUTS. DIAM.	1 3/16"	I.W.G. No. 9
	SUPERHEATER TUBES	28	" "	5¼"	" " 8
	SMALL TUBES:	148	" "	1⅞"	" " 11

DISTANCE BETWEEN TUBEPLATES: 13'-10"

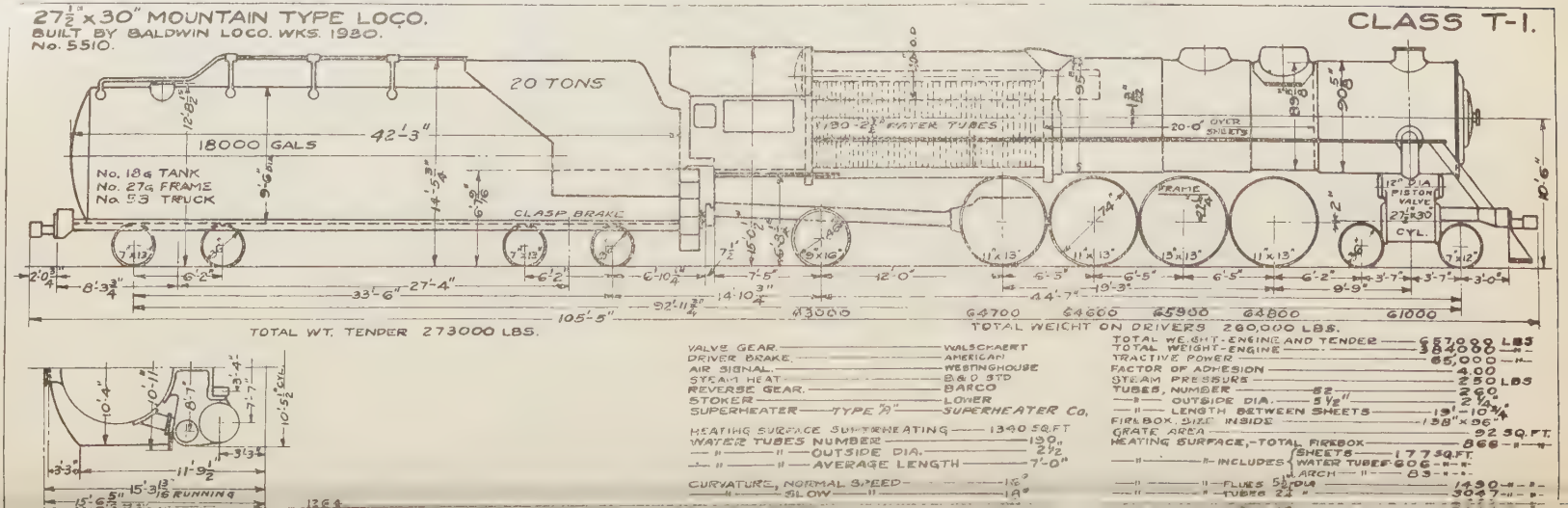
HEATING SURFACE	TUBES:	1538	Sq. FT.
	FIREBOX	162	" "
	THERMIC SYPHONS	—	" "
	SUPERHEATER	354	" "

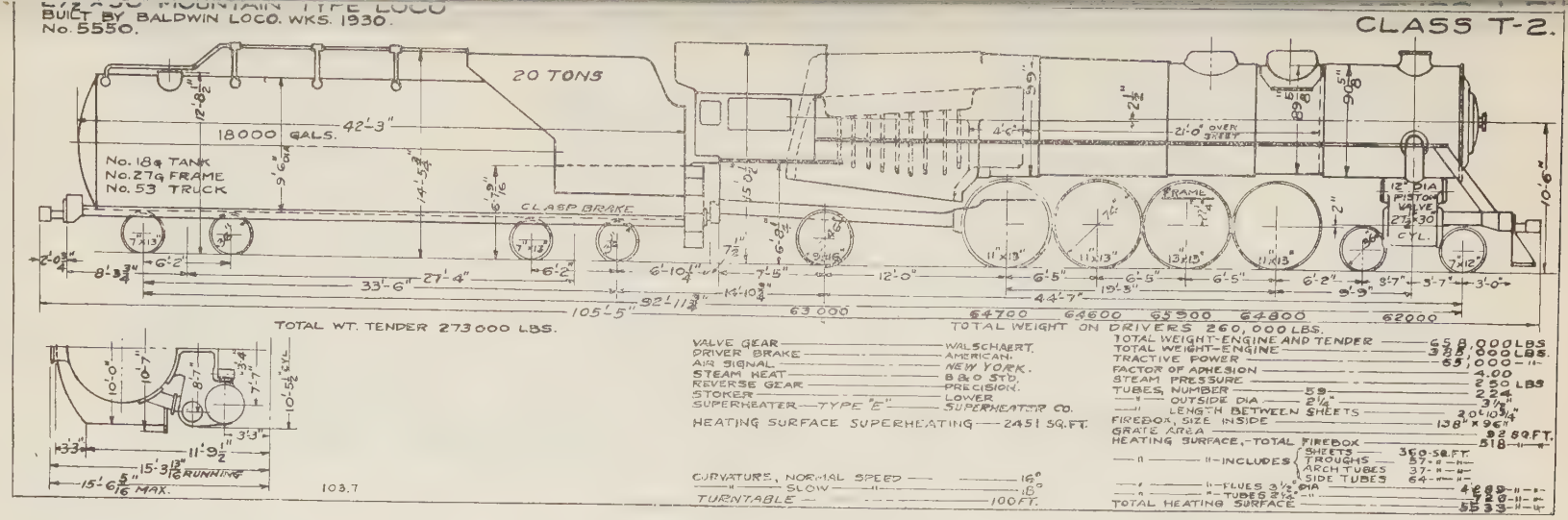
TOTAL EVAPORATIVE: 1700 SQ. FT.

APPENDIX L/6. — 4-6-4 engine (modified to take tender). — Buenos Ayres and Pacific Railway.

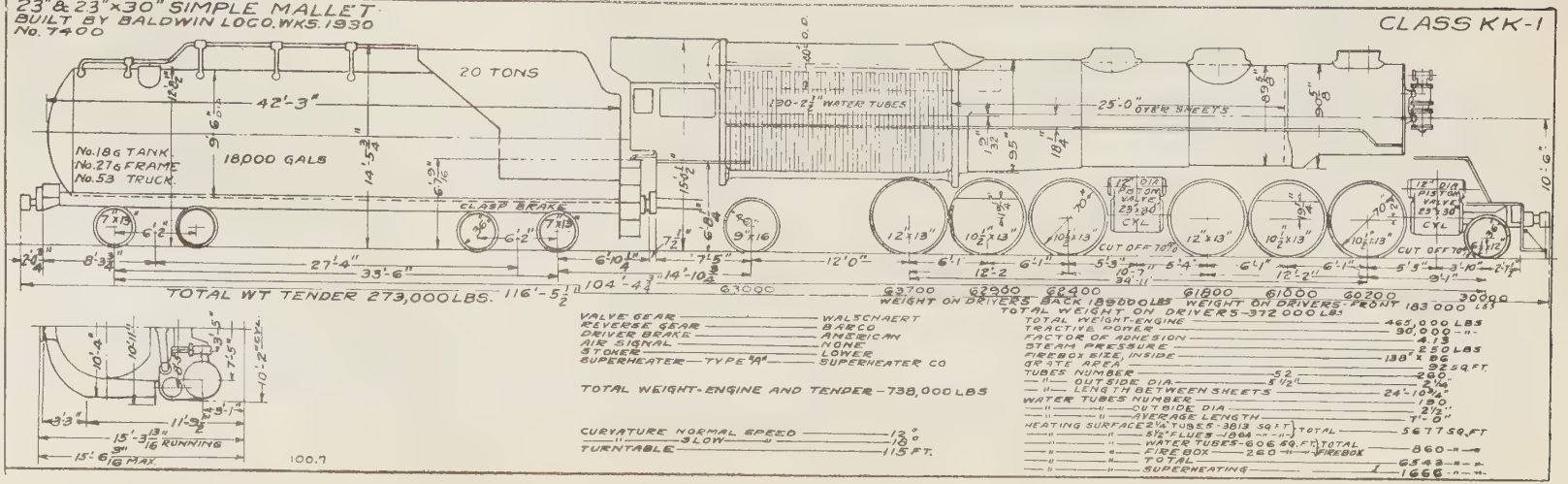

TYPE SKETCH No 6.
LOADED WEIGHT 29·2 18·5 19·2 18·0 32·35 36·0
TOTAL LOADED 153·25
TOTAL EMPTY 119·80
RAILWAY: BUENOS AIRES AND PACIFIC
TYPE: 4-6-4-4 ARTICULATED
PUT INTO SERVICE: CONVERTED 1935
TRACTIVE EFFORT AT 85% BP 35,600 LBS
MOTION: WALSCHAERT
VALVES: PISTON 10" DIAM
MAX VALVE TRAVEL 6 3/8"
STEAM LAP: 1 1/4" EXHAUST LAP NIL
TOTAL ADHESIVE WEIGHT: 55·7 TONS
ADHESIVE FACTOR: 2·75
BRAKE % OF ENGINE: 58·5 % TENDER
RAD OF MIN CURVE 7·5 CHAINS
BOILER
GRATE AREA: 87 SQ.FT.
FIREBOX VOLUME 204 CUB FT.
TUBES: SUPERHEATER ELEMENTS: 28 OUTS DIAM 5 1/4" L.W.G No 9
SUPERHEATER TUBES: 28 " " 5 1/4" " " 8
SMALL TUBES 148 " " 1 3/4" " " 11
DISTANCE BETWEEN TUBEPLATES 13'-10"
TUBES: 1,530 Sq.Ft.
FIREBOX 162 " "
THERMIX SYPHONS — " "
SUPERHEATER 354 " "
TOTAL EVAPORATIVE: 1,700 SQ FT.

APPENDIX L/7. — T/1, 4-8-2 passenger engine. — Baltimore and Ohio Railroad.

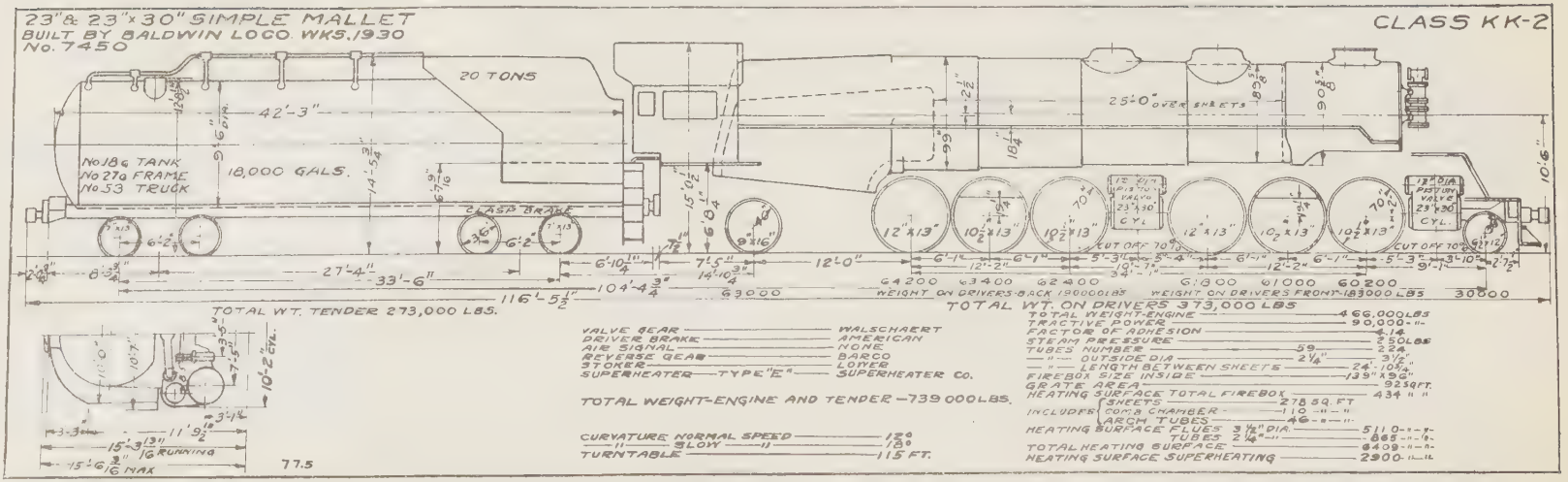

27½" x 30" MOUNTAIN TYPE LOCO.
BUILT BY BALDWIN LOCO. WKS. 1930.
No. 5510.
CLASS T-1.
20 TONS
18000 GALS
No. 18G TANK
No. 27G FRAME
No. 53 TRUCK
CLASP BRAKE
TOTAL WT. TENDER 273000 LBS.
TOTAL WEIGHT ON DRIVERS 290000 LBS.
VALVE GEAR — WALSCHAERT
DRIVER BRAKE — AMERICAN
AIR SIGNAL — WESTINGHOUSE
STEAM HEAT — B&O STD
REVERSE GEAR — BARCO
STOKER — LOWER
SUPERHEATER — TYPE "A" — SUPERHEATER Co.
HEATING SURFACE SUPERHEATING — 1340 SQ.FT
WATER TUBES NUMBER — 190
" " OUTSIDE DIA. — 2½"
" " AVERAGE LENGTH — 7'-0"
CURVATURE, NORMAL SPEED — 16°
" SLOW — 19°
TOTAL WEIGHT-ENGINE AND TENDER — 657000 LBS
TOTAL WEIGHT-ENGINE — 384000 "
TRACTIVE POWER — 65,000 "
FACTOR OF ADHESION — 4.00
STEAM PRESSURE — 250 LBS
TUBES, NUMBER — 52 — 260
" OUTSIDE DIA. — 5½" — 2¼"
" LENGTH BETWEEN SHEETS — 13'-10¾"
FIREBOX, SIZE INSIDE — 138" x 96"
GRATE AREA — 92 SQ.FT.
HEATING SURFACE,-TOTAL FIREBOX — 866 "
" " INCLUDES SHEETS — 177 SQ.FT.
WATER TUBES — 606 "
ARCH — 83 "
" " FLUES 5½" DIA — 1490 "
" " TUBES 2¼" — 3047 "


2-8-2 MOUNTAIN TYPE LOCO
BUILT BY BALDWIN LOCO. WKS. 1930.
No. 5550.
CLASS T-2.
20 TONS
18000 GALS.
42'-3"
No. 18 TANK
No. 27 FRAME
No. 53 TRUCK
CLASP BRAKE
21'-0" OVER PISTONS
12" DIA PISTON VALVE 27"-30 CYL.
TOTAL WT. TENDER 273 000 LBS.
TOTAL WEIGHT ON DRIVERS 260,000 LBS.
64700 64600 65300 64800 62000
VALVE GEAR — WALSCHAERT.
DRIVER BRAKE — AMERICAN.
AIR SIGNAL — NEW YORK.
STEAM HEAT — B & O STD.
REVERSE GEAR — PRECISION.
STOKER — LOWER
SUPERHEATER — TYPE "E" — SUPERHEATER CO.
HEATING SURFACE SUPERHEATING — 2451 SQ. FT.
CURVATURE, NORMAL SPEED — 16°
" SLOW — 18°
TURNTABLE — 100 FT.
TOTAL WEIGHT-ENGINE AND TENDER — 658,000 LBS
TOTAL WEIGHT-ENGINE — 385,000 LBS.
TRACTIVE POWER — 65,000 LBS.
FACTOR OF ADHESION — 4.00
STEAM PRESSURE — 250 LBS
TUBES, NUMBER — 59 — 224
" OUTSIDE DIA — 2 1/4" — 3 1/4"
" LENGTH BETWEEN SHEETS — 20'-10 3/4"
FIREBOX, SIZE INSIDE — 138" X 96"
GRATE AREA — 92 SQ.FT.
HEATING SURFACE, - TOTAL FIREBOX — 518
" " - INCLUDES SHEETS 360 SQ.FT.
" " TROUGHS 57 " "
" " ARCH TUBES 37 " "
" " SIDE TUBES 64 " "
" " - FLUES 2 1/4" DIA — 4685 " "
" " - TUBES 3 1/2" " — 2110 " "
TOTAL HEATING SURFACE — 5533 " "
103.7

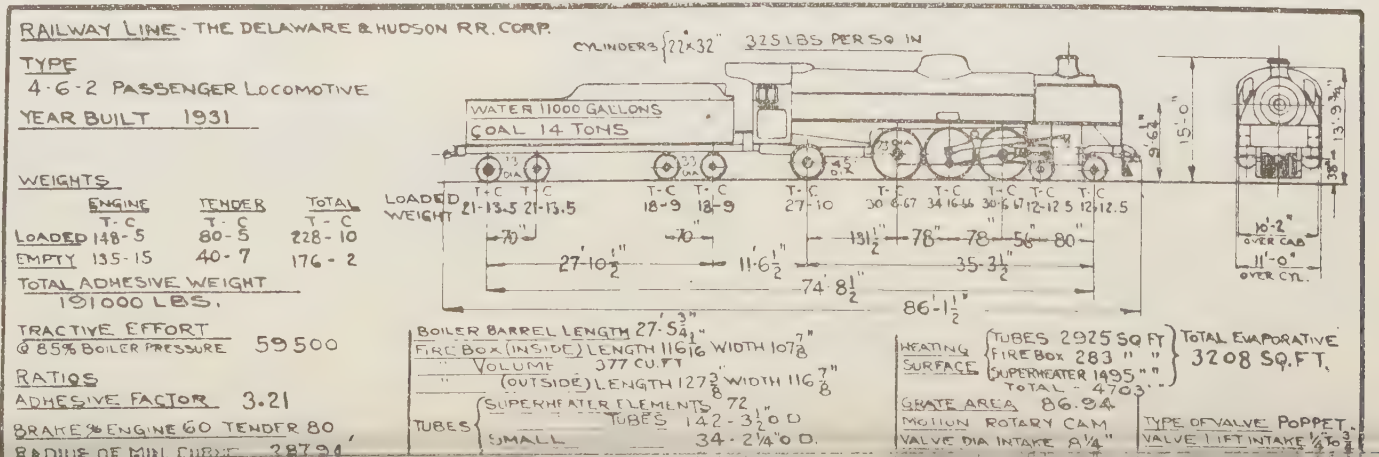
APPENDIX L/9. — KK/1, 2-6-6-2 freight engine. — Baltimore and Ohio Railroad.


23" & 23" x 30" SIMPLE MALLET.
BUILT BY BALDWIN LOCO. WKS. 1930
No. 7400
CLASS KK-1
20 TONS
18000 GALS
42'-3"
No. 18 G TANK
No. 27 G FRAME
No. 53 TRUCK
CLASP BRAKE
130-2 1/4" WATER TUBES
25'-0" OVER SHEETS
TOTAL WT TENDER 273,000 LBS.
TOTAL WEIGHT ON DRIVERS BACK 185000 LBS WEIGHT ON DRIVERS - FRONT 183 000 LBS
TOTAL WEIGHT ON DRIVERS - 372 000 LBS
VALVE GEAR — WALSCHAERT
REVERSE GEAR — BARCO
DRIVER BRAKE — AMERICAN
AIR SIGNAL — NONE
STOKER — LOWER
SUPERHEATER — TYPE "A" — SUPERHEATER CO
TOTAL WEIGHT-ENGINE AND TENDER — 738,000 LBS
CURVATURE NORMAL SPEED — 12°
" SLOW — 18°
TURNTABLE — 115 FT.
TOTAL WEIGHT-ENGINE — 465,000 LBS
TRACTIVE POWER — 90,000 "
FACTOR OF ADHESION — 4.13
STEAM PRESSURE — 250 LBS
FIREBOX SIZE, INSIDE — 138" X 96"
GRATE AREA — 92.5 SQ.FT.
TUBES NUMBER — 52 — 280
" OUTSIDE DIA — 5 1/2" — 2 1/4"
" LENGTH BETWEEN SHEETS — 24'-10 3/4"
WATER TUBES NUMBER — 130
" OUTSIDE DIA — 2 1/2" "
" AVERAGE LENGTH — 7'-5"
HEATING SURFACE 2 1/4" TUBES - 3813 SQ.FT. TOTAL — 5677 SQ.FT
" " 5 1/2" FLUES - 1864 " " "
" " WATER TUBES - 606 SQ.FT. TOTAL — 860 " "
" " FIREBOX — 260 " " FIREBOX
" " TOTAL — 6543 " "
" " SUPERHEATING — 1666 " "
100.7

APPENDIX L/10. — KK/2, 2-6-6-2 freight engine. — Baltimore and Ohio Railroad.


23"& 23"x 30" SIMPLE MALLET
BUILT BY BALDWIN LOCO. WKS. 1930
No. 7450
CLASS KK-2
20 TONS
42'-3"
No 186 TANK
No 27a FRAME
No 53 TRUCK
18,000 GALS.
2 CASP BRAKE
25'-0" OVER SHEETS
TOTAL WT. TENDER 273,000 LBS.
TOTAL WT. ON DRIVERS 373,000 LBS
TOTAL WEIGHT-ENGINE 466,000 LBS
TRACTIVE POWER 90,000 "
FACTOR OF ADHESION 4.14
STEAM PRESSURE 250 LBS
TUBES NUMBER 224
OUTSIDE DIA 2¼" 3½"
LENGTH BETWEEN SHEETS 24'-10¾"
FIREBOX SIZE INSIDE 139" X 96"
GRATE AREA 92 SQ FT.
HEATING SURFACE TOTAL FIREBOX 434 " "
SHEETS 278 SQ FT
INCLUDES COMB CHAMBER 110 " "
ARCH TUBES 46 " "
HEATING SURFACE FLUES 3½" DIA 5110 " "
TUBES 2¼" " 865 " "
TOTAL HEATING SURFACE 6409 " "
HEATING SURFACE SUPERHEATING 2300 " "
VALVE GEAR WALSCHAERT
DRIVER BRAKE AMERICAN
AIR SIGNAL NONE
REVERSE GEAR BARCO
STOKER LOWER
SUPERHEATER TYPE "E" SUPERHEATER CO.
TOTAL WEIGHT-ENGINE AND TENDER — 739 000 LBS.
CURVATURE NORMAL SPEED 12°
SLOW 18°
TURNTABLE 115 FT.
77.5

APPENDIX L/11. — 4-6-2 passenger engine. — Delaware and Hudson Company.

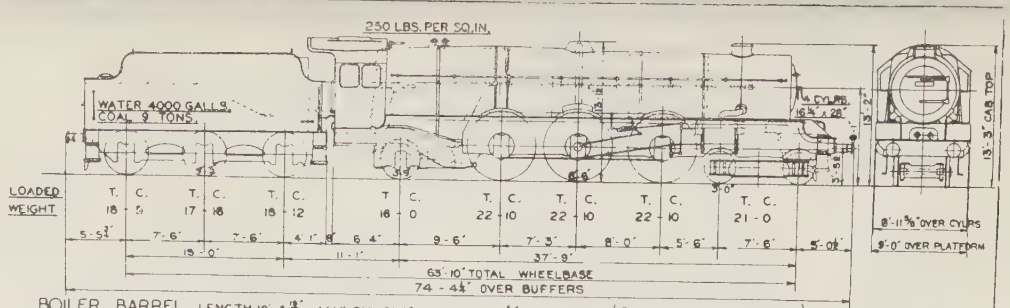

RAILWAY LINE - THE DELAWARE & HUDSON RR. CORP.
TYPE
4-6-2 PASSENGER LOCOMOTIVE
YEAR BUILT 1931
WEIGHTS
ENGINE T-C
TENDER T-C
TOTAL T-C
LOADED 148-5 80-5 228-10
EMPTY 135-15 40-7 176-2
TOTAL ADHESIVE WEIGHT 191000 LBS.
TRACTIVE EFFORT @ 85% BOILER PRESSURE 59500
RATIOS
ADHESIVE FACTOR 3.21
BRAKE % ENGINE 60 TENDER 80
RADIUS OF MIN CURVE 387'-9"
CYLINDERS 22"x32" 325 LBS PER SQ IN
WATER 11000 GALLONS
COAL 14 TONS
LOADED WEIGHT
21-13.5 21-13.5 18-9 18-9 27-10 30-6.67 34-16.66 30-6.67 12-12.5 12-12.5
27'-10½" 11'-6½" 74'-8½" 86'-1½"
BOILER BARREL LENGTH 27'-5¾"
FIRE BOX (INSIDE) LENGTH 116/16 WIDTH 107/8"
VOLUME 377 CU FT
(OUTSIDE) LENGTH 127¾" WIDTH 116 7/8"
TUBES SUPERHEATER ELEMENTS 72
TUBES 142 - 3½" O.D.
SMALL 34 - 2¼" O.D.
HEATING SURFACE TUBES 2925 SQ FT
FIRE BOX 283 " "
SUPERHEATER 1495 " "
TOTAL - 4703 " "
TOTAL EVAPORATIVE 3208 SQ. FT.
GRATE AREA 86.94
MOTION ROTARY CAM
VALVE DIA INTAKE 8¼"
TYPE OF VALVE POPPET
VALVE LIFT INTAKE ½ TO ¾
10'-2" OVER CAB
11'-0" OVER CYL.

RAILWAY L M S
TYPE. 7P
4 - 6 - 2 PASSENGER ENGINE.
YEAR BUILT 1935.

WEIGHTS.

	ENGINE T. - C.	TENDER T - C.	TOTAL T. - C.
LOADED	104 - 10	54 - 13	159 - 3
EMPTY	94 - 7½	27 - 16	122 - 3½

TOTAL ADHESIVE WEIGHT
151,200 LBS.
TRACTIVE EFFORT
AT 85 % BOILER PRESS. 40,300
RATIOS.
ADHESION FACTOR 3·75
BRAKE % ENGINE & TENDER 53·77
RADIUS OF MIN. CURVE 6 CHAINS.


250 LBS. PER SQ. IN.
WATER 4000 GALLS.
COAL 9 TONS.
4 CYLRS. 15½ x 28
13'-2" CAB TOP
13'-3" CAB TOP
LOADED WEIGHT
T. C. T. C. T. C. T. C. T. C. T. C. T. C. T. C. T. C.
18 - 5 17 - 18 18 - 12 18 - 0 22 - 10 22 - 10 22 - 10 21 - 0
5'-5½" 7'-6" 7'-6" 4'-1" 6 4" 9'-6" 7'-3" 8'-0" 5'-6" 7'-6" 5'-0½"
15'-0" 11'-1" 37'-9"
63'-10" TOTAL WHEELBASE
74'-4½" OVER BUFFERS
8'-11⅜" OVER CYLRS
8'-0" OVER PLATFORM

BOILER BARREL. LENGTH 19'-5⅛" MAX. DIA. 6'-3" MIN. DIA. 5'-8⅛"
FIREBOX (INSIDE). LENGTH 7'-7½" WIDTH 6'-0⅝" HEIGHT 8'-10½"
" VOLUME. 261 CUB. FT.
" (OUTSIDE) LENGTH 8'-6" WIDTH 6'-10¾" HEIGHT 8'-11⅝"
TUBES: SUPERHEATER ELEMENTS 32 OUTS. DIA. 1½" x 11 S.W.G.
" TUBES 32 " " 5⅛" x 7 . . .
" SMALL " 112 " " 2¼" x 11 . . .
DISTANCE BETWEEN TUBEPLATES 19'-3"

HEATING SURFACE: TUBES 2097 SQ. FT. } TOTAL EVAPORATIVE
FIREBOX 217 " " } 2314 SQ. FT.
SUPERHEAT 623 " "
TOTAL 2937 " "
GRATE AREA 45 " "
MOTION: INSIDE WALSCHAERT
OUTSIDE "
VALVE DIA. 8"
STEAM LAP: INSIDE 1¾" OUTSIDE 1¾"
TYPE OF VALVE - PISTON
VALVE TRAVEL (MAX) 7·31
EXHAUST LAP. NIL.

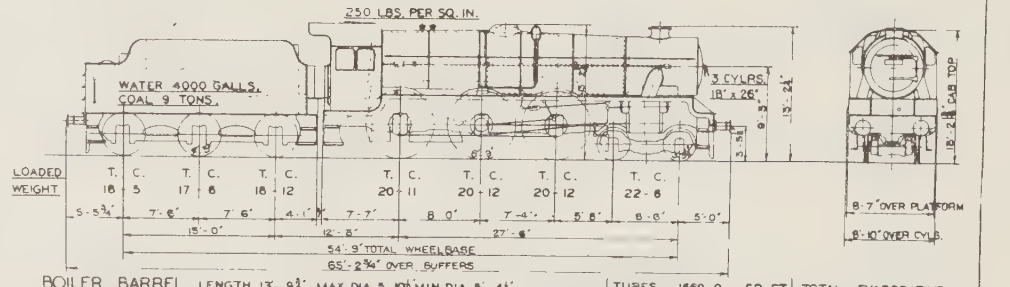
APPENDIX L/13. — 6P, 4-6-0 express passenger engine. — London, Midland and Scottish Railway.

RAILWAY L M S
TYPE. 6P
4 - 6 - 0 PASSENGER ENGINE.
YEAR BUILT 1936

WEIGHTS.

	ENGINE T. - C.	TENDER T - C.	TOTAL T. - C.
LOADED	84 - 1	54 - 13	138 - 14
EMPTY	77 - 14	27 - 16	105 - 10

TOTAL ADHESIVE WEIGHT
138,320 LBS.
TRACTIVE EFFORT
AT 85 % BOILER PRESS. 33,150
RATIOS.
ADHESION FACTOR 4·17
BRAKE % ENGINE & TENDER 52·9
RADIUS OF MIN. CURVE 6 CHAINS.


250 LBS. PER SQ. IN.
WATER 4000 GALLS.
COAL 9 TONS.
3 CYLRS. 18" x 26"
13'-2½" CAB TOP
13'-2" CAB TOP
LOADED WEIGHT
T. C. T. C. T. C. T. C. T. C. T. C. T. C. T. C.
18 - 5 17 - 6 18 - 12 20 - 11 20 - 12 20 - 12 22 - 6
5'-5¾" 7'-6" 7'-6" 4'-1" 7'-7" 8'-0" 7'-4½" 5'-8" 6'-6" 5'-0"
15'-0" 12'-8" 27'-8"
54'-9" TOTAL WHEELBASE
65'-2¾" OVER BUFFERS
8'-7" OVER PLATFORM
8'-10" OVER CYLS.

BOILER BARREL. LENGTH 13'-9¾" MAX. DIA. 5'-10⅝" MIN. DIA. 5'-4½"
FIREBOX (INSIDE). LENGTH 9'-5½" WIDTH 3'-3" HEIGHT 6'-9⅛"
" VOLUME. 210 CUB. FT.
" (OUTSIDE) LENGTH 10'-3" WIDTH 4'-0¼" HEIGHT 8'-10½"
TUBES: SUPERHEATER ELEMENTS 28 OUTS. DIA. 1⅝" x 11 S.W.G.
" TUBES 28 " " 5⅛" x 7 . . .
" SMALL " 143 " " 2⅛" x 11 . . .
DISTANCE BETWEEN TUBEPLATES 14'-3"

HEATING SURFACE: TUBES 1659·0 SQ. FT. } TOTAL EVAPORATIVE
FIREBOX 195·0 " " } 1864·0 SQ. FT.
SUPERHEAT 360·0 " "
TOTAL 2224·0 " "
GRATE AREA 31·25 " "
MOTION: INSIDE WALSCHAERT
OUTSIDE WALSCHAERT.
VALVE DIA. 9"
STEAM LAP: INSIDE 1⅛" OUTSIDE 1⅛"
TYPE OF VALVE - PISTON
VALVE TRAVEL (MAX) 6·41
EXHAUST LAP. NIL.

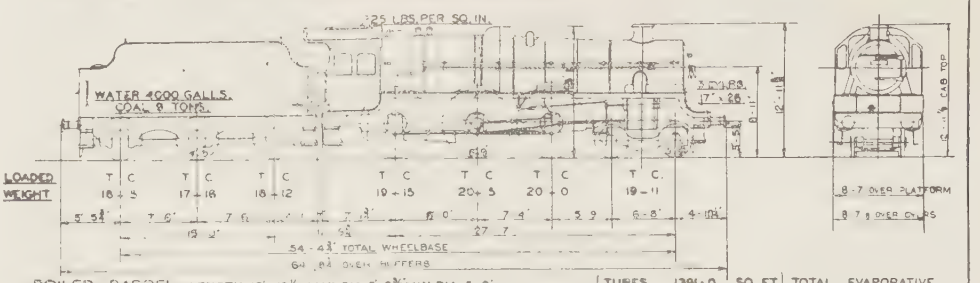
APPENDIX L/14. — 5XP, 4-6-0 express passenger engine. — London, Midland and Scottish Railway.

RAILWAY L M S
TYPE 5 X P.
4-6-0 PASSENGER ENGINE.
YEAR BUILT 1935

WEIGHTS.

	ENGINE T. C.	TENDER T. C.	TOTAL T. C.
LOADED	79 – 11	54 – 13	134 – 4
EMPTY	73 – 5½	27 – 16	101 – 1½

TOTAL ADHESIVE WEIGHT
134,400 LBS.
TRACTIVE EFFORT
AT 85% BOILER PRESS. 26,610 LBS.
RATIOS
ADHESION FACTOR 5·05
BRAKE % ENGINE & TENDER 51·24
RADIUS OF MIN. CURVE 6 CHAINS.



LOADED WEIGHT: T C 18 + 5 | T C 17 + 18 | T C 18 + 12 | T C 19 + 13 | T C 20 + 5 | T C 20 + 0 | T C 19 – 11

BOILER BARREL. LENGTH 12'-10⅛ MAX. DIA. 5'-8⅜" MIN. DIA. 5'-0"
FIREBOX (INSIDE). LENGTH 8'-3⁷/₁₆" WIDTH 3'-3⅜" HEIGHT 6'-8⅝"
VOLUME 203 CUB. FT.
(OUTSIDE) LENGTH 10'-4" WIDTH 4'-0" HEIGHT 8'-9³²/₃₂"
TUBES: SUPERHEATER ELEMENTS 21 OUTS. DIA. 5⅛" S.W.G. 5⅛ x 7
TUBES 21 " 5⅛ x 7
SMALL " 138 " 2" x 11
DISTANCE BETWEEN TUBEPLATES 13-3

HEATING SURFACE: TUBES 1391·0 SQ. FT. | FIREBOX 181·1 " " | SUPERHEAT 235·0 | TOTAL 1807·1 | TOTAL EVAPORATIVE 1572·1 SQ. FT.
GRATE AREA 31 " "
MOTION: INSIDE WALSCHAERT OUTSIDE
VALVE DIA. 9
STEAM LAP: INSIDE 1⅞ OUTSIDE 1⅞
TYPE OF VALVE - PISTON
VALVE TRAVEL (MAX) 6·42
EXHAUST LAP, NIL.

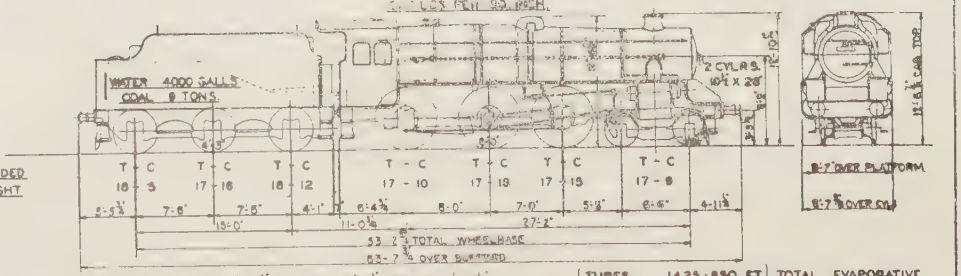
APPENDIX L/15. — 5P/5F, 4-6-0 mixed traffic engine. — London, Midland and Scottish Railway.

RAILWAY L M S
TYPE. 5P, 5F.
4-6-0 MIXED TRAFFIC ENGINE
YEAR BUILT 1935

WEIGHTS.

	ENGINE T. C.	TENDER T. C	TOTAL T. C.
LOADED	70 - 12	54 - 13	125 - 5
EMPTY	64 - 2	27 - 16	91 - 18

TOTAL ADHESIVE WEIGHT
119,056 LBS.
TRACTIVE EFFORT
AT 85% BOILER PRESS. 25,455 LBS
RATIOS.
ADHESION FACTOR 4·67
BRAKE % ENGINE & TENDER 57·1.
RADIUS OF MIN. CURVE 6 CHAINS



LOADED WEIGHT: T C 18 - 3 | T C 17 - 16 | T C 18 - 12 | T C 17 - 10 | T C 17 - 13 | T C 17 - 15 | T C 17 - 8

BOILER BARREL. LENGTH 13'-10⅛ MAX. DIA. 5'-8½ MIN. DIA. 4'-11⅛
FIREBOX (INSIDE). LENGTH 8'-4⅛ WIDTH 3'-2⅝ HEIGHT 6'-8⅝
VOLUME 166 CUB. FT.
(OUTSIDE) LENGTH 9'-2⅝ WIDTH 3'-11⅝ HEIGHT 8'-9³²/₃₂
TUBES: SUPERHEATER ELEMENTS 21 OUTS. DIA. 5⅛" S.W.G. 5⅛ x 7
TUBES 21 " 5⅛ x 7
SMALL " 136 " 2" x 11
DISTANCE BETWEEN TUBEPLATES 14-3

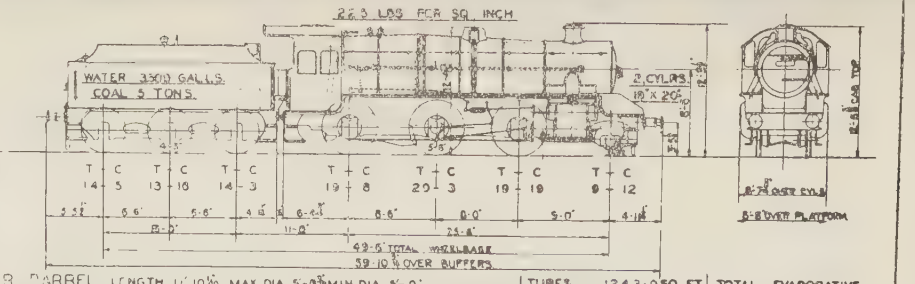
HEATING SURFACE: TUBES 1425·8 SQ. FT. | FIREBOX 155·0 " " | SUPERHEAT 256·2 " " | TOTAL 1837·0 " " | TOTAL EVAPORATIVE 1560·8 SQ. FT.
GRATE AREA 27·8 " "
MOTION: INSIDE OUTSIDE WALSCHAERT
VALVE DIA. 10"
STEAM LAP: INSIDE 1⅛ OUTSIDE 1¼
TYPE OF VALVE - PISTON
VALVE TRAVEL (MAX) 6·4 3
EXHAUST LAP, 1/16

RAILWAY L M S
TYPE. 5 P, 4 F.
2-6-0 GOODS ENGINE.
YEAR BUILT 1935.

WEIGHTS.

	ENGINE T. C.	TENDER T. C	TOTAL T. C
LOADED	69 - 2	42 - 4	111 - 6
EMPTY	63 - 5	21 - 11½	84 - 16½

TOTAL ADHESIVE WEIGHT
133,280 LBS.
TRACTIVE EFFORT
AT 85% BOILER PRESS. 23,288 LBS.
RATIOS
ADHESION FACTOR 5·07
BRAKE % ENGINE & TENDER 74·03
RADIUS OF MIN. CURVE 6 CHAINS.


22·3 LBS PER SQ. INCH
WATER 3500 GALLS.
COAL 5 TONS.
2 CYLS. 19" X 26"
LOADED WEIGHT
T C T C T C T C T C T C T C
14 5 13 10 14 3 19 8 20 3 19 18 9 12
42·9" TOTAL WHEELBASE
59·10½" OVER BUFFERS
8'-3" OVER CYLS.
8'-8" OVER PLATFORM

BOILER BARREL. LENGTH 11'-10⅝ MAX. DIA. 5'-8⅜ MIN. DIA. 5'-0"
FIREBOX (INSIDE) LENGTH 8'-4⅝ WIDTH 3'-3" HEIGHT 6'-8⅝
" VOLUME. 166 CUB. FT.
" (OUTSIDE) LENGTH 9'-3" WIDTH 4'-0" HEIGHT 8'-9½
TUBES: SUPERHEATER ELEMENTS 14 OUTS. DIA. 5⅛ X 11 S.W.G.
" TUBES 14 " " 5⅛ X 7 . . .
SMALL " 138 " " 2" X 11 . . .
DISTANCE BETWEEN TUBEPLATES 12 - 3"

HEATING SURFACE: TUBES 1243·0 SQ. FT. | FIREBOX 155·0 . . | SUPERHEAT 185·2 . . | TOTAL 1583·2 . . — TOTAL EVAPORATIVE 1388 SQ. FT.
GRATE AREA 27·8 . .
MOTION: INSIDE — | OUTSIDE WALSCHAERT
VALVE DIA. 10"
STEAM LAP: INSIDE | OUTSIDE 1½
TYPE OF VALVE - PISTON
VALVE TRAVEL (MAX) 6·63"
EXHAUST LAP ⅛

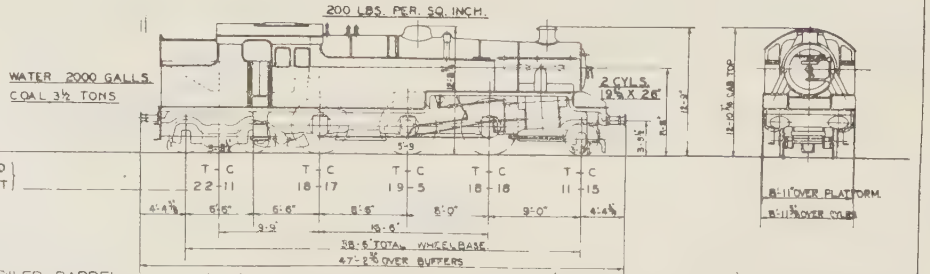
APPENDIX L/17. - 4P, 2-6-4 suburban passenger tank engine. — London, Midland and Scottish Railway.

RAILWAY LMS
TYPE 4 P.
2-6-4 TANK ENGINE.
YEAR BUILT 1936.

WEIGHTS

	TOTAL WEIGHTS T. - C.
LOADED	91 - 6
EMPTY	73 - 12

TOTAL ADHESIVE WEIGHT
127,680 LBS.
TRACTIVE EFFORT
AT 85% BOILER PRESS. 24,670 LBS.
RATIOS
ADHESION FACTOR 5·18
BRAKE % ENGINE 45·6
RADIUS OF MIN. CURVE 6 CHAINS.


200 LBS. PER SQ. INCH.
WATER 2000 GALLS.
COAL 3½ TONS
2 CYLS. 19½ X 26"
LOADED WEIGHT
T C T C T C T C T C
22 11 18 17 19 5 18 18 11 15
38·6" TOTAL WHEELBASE
47·2⅝" OVER BUFFERS
8'-11" OVER PLATFORM.
8'-11" OVER CYLS.

BOILER BARREL LENGTH 11'-10⅝ MAX. DIA. 5'-3" MIN. DIA. 4'-9"
FIREBOX (INSIDE) LENGTH 7'-9⅛ WIDTH 3'-4⅛ HEIGHT 6'-4"
" VOLUME 39 CUB. FT.
" (OUTSIDE) LENGTH 8'-6" WIDTH 4'-0½ HEIGHT 8'-5⅛
TUBES: SUPERHEATER ELEMENTS 18 OUTS. DIA. 1⅝ X 11 S.W.G.
" TUBES 18 " " 5⅛ X 7 . . .
SMALL " 148 " " 1⅜ X 11 . . .
DISTANCE BETWEEN TUBEPLATES 12 - 3"

HEATING SURFACE: TUBES 1126·0 SQ. FT. | FIREBOX 138·0 " | SUPERHEAT 185·0 " | TOTAL 1450·0 " " — TOTAL EVAPORATIVE 1265 SQ. FT.
GRATE AREA 26·7 " "
MOTION: INSIDE | OUTSIDE WALSCHAERT
VALVE DIA. 10"
STEAM LAP: INSIDE | OUTSIDE 1"
TYPE OF VALVE - PISTON
VALVE TRAVEL (MAX) 6·22"
EXHAUST LAP NIL

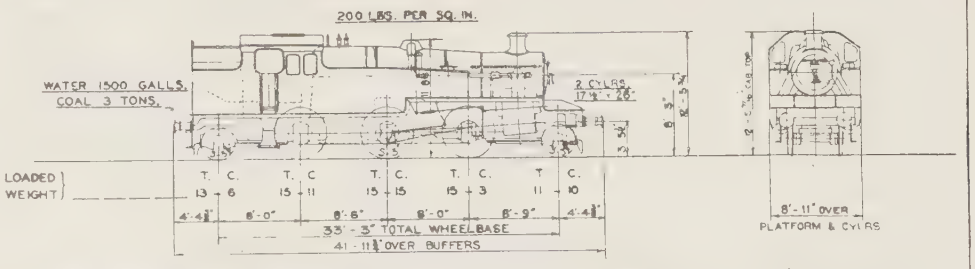
APPENDIX L/18. — 3P, 2-6-2 mixed traffic tank engine. — London, Midland and Scottish Railway.

RAILWAY LMS
TYPE 3P.
2-6-2 TANK ENGINE.
YEAR BUILT 1935.

WEIGHTS

	TOTAL WEIGHTS T. - C.
LOADED	71 - 5
EMPTY	57 - 11

TOTAL ADHESIVE WEIGHT
104,048 LBS.
TRACTIVE EFFORT
AT 85 % BOILER PRESS. 21,486 LBS
RATIOS
ADHESION FACTOR 4·84
BRAKE % ENGINE 48·13
RADIUS OF MIN. CURVE 6 CHAINS.


200 LBS. PER SQ. IN.
WATER 1500 GALLS.
COAL 3 TONS.
2 CYLRS. 17½" × 28"
LOADED WEIGHT
T. C. T. C. T. C. T. C. T C.
13 + 6 15 + 11 15 + 15 15 + 3 11 + 10
4'-4½" 6'-0" 6'-6" 8'-0" 8'-9" 4'-4½"
33'-3" TOTAL WHEELBASE
41'-11¾" OVER BUFFERS
8'-11" OVER PLATFORM & CYLRS

BOILER BARREL LENGTH 10'-5¾" MAX. DIA. 4'-9" MIN. DIA. 4'-2"
FIREBOX (INSIDE) LENGTH 5'-8 11/16" WIDTH 3'-4¼" HEIGHT 5'-11⅞"
" VOLUME 102 CUB. FT.
" (OUTSIDE) LENGTH 8'-5" WIDTH 4'-0½" HEIGHT 8'-0⅝"
TUBES: SUPERHEATER ELEMENTS 7 OUTS. DIA. 1⅝" × 11 S.W.G.
TUBES 7 " " 5⅛" × 7 . . .
SMALL 152 " " 1¾" × 11 " . .
DISTANCE BETWEEN TUBEPLATES 12'-10½"

HEATING SURFACE			
TUBES	858·1	SQ. FT.	TOTAL EVAPORATIVE
FIREBOX	108 9	" "	966 SQ. FT.
SUPERHEAT	72 8	" "	
TOTAL	1038 8	" "	
GRATE AREA	19·2	" "	

MOTION: INSIDE — OUTSIDE WALSCHAERT. TYPE OF VALVE - PISTON
VALVE DIA. 8"
STEAM LAP: INSIDE — OUTSIDE 1½" VALVE TRAVEL (MAX) 6·35"
EXHAUST LAP NIL. ¢

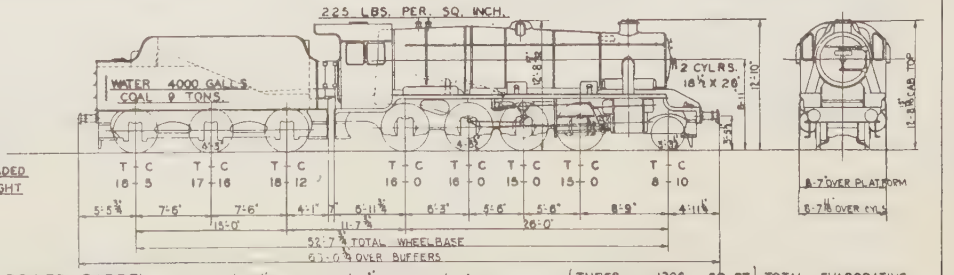
APPENDIX L/19. — 8F, 2-8-0 freight engine. — London, Midland and Scottish Railway.

RAILWAY L M S
TYPE. 8 F.
2-8-0 FREIGHT ENGINE.
YEAR BUILT 1935.

WEIGHTS.

	ENGINE T. - C.	TENDER T. - C.	TOTAL T. - C.
LOADED	70 - 10.	54 - 13.	125-3.
EMPTY	63 - 16½.	27 - 16.	91 - 12½

TOTAL ADHESIVE WEIGHT
138,880 LBS.
TRACTIVE EFFORT
AT 85 % BOILER PRESS. 32,438 LBS.
RATIOS.
ADHESION FACTOR 4·28
BRAKE % ENGINE & TENDER 65·33
RADIUS OF MIN. CURVE 6 CHAINS.

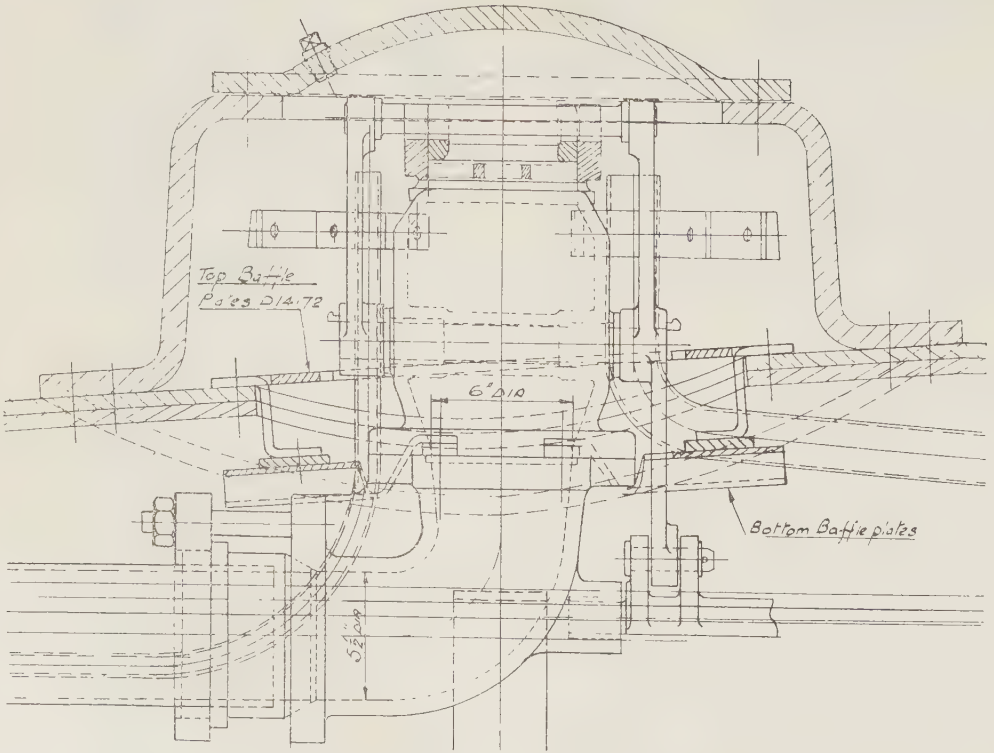

225 LBS. PER SQ. INCH.
WATER 4000 GALLS.
COAL 9 TONS.
2 CYLRS. 18½" X 28"
LOADED WEIGHT
T C T C T C T C T C T C T C T C
18 - 5 17 - 16 18 - 12 16 - 0 16 - 0 15 - 0 15 - 0 8 - 10
5'-5⅜" 7'-5" 7'-6" 4'-1" 5'-11⅜" 6'-3" 5'-6" 5'-6" 8'-9" 4'-11⅛"
15'-0" 11'-7⅜" 26'-0"
52'-7¾" TOTAL WHEELBASE
60'-0¾" OVER BUFFERS
8'-7" OVER PLATFORM
8'-7⅛" OVER CYLS.

BOILER BARREL. LENGTH 12'-10⅛" MAX. DIA. 5' 8⅝" MIN. DIA. 5'-0"
FIREBOX (INSIDE). LENGTH 8'-4 15/16" WIDTH 3'-2⅝" HEIGHT 6'-8⅝"
" VOLUME. 166 CUB. FT.
" (OUTSIDE) LENGTH 9'-3" WIDTH 4'-0" HEIGHT 8'-9 23/32"
TUBES: SUPERHEATER ELEMENTS 21 OUTS. DIA. 1⅝" X 11 S.W.G.
" TUBES 21 " " 5⅛" X 7 . . .
SMALL " 136 " " 2" X 11 . . .
DISTANCE BETWEEN TUBEPLATES 13' 3"

HEATING SURFACE			
TUBES	1,308	SQ. FT.	TOTAL EVAPORATIVE
FIREBOX	155	" "	1,463 SQ. FT.
SUPERHEAT	235.	" "	
TOTAL	1698	" "	
GRATE AREA	27·8	" "	

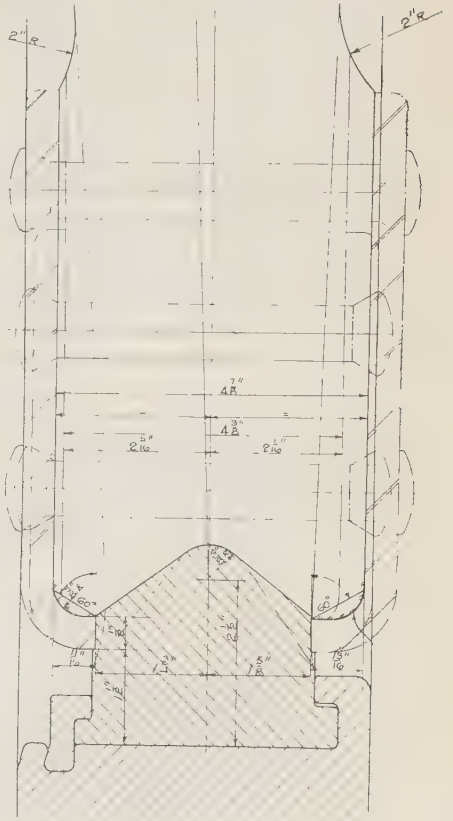
MOTION: INSIDE — OUTSIDE WALSCHAERT. TYPE OF VALVE - PISTON
VALVE DIA. 10"
STEAM LAP: INSIDE — OUTSIDE 1½" VALVE TRAVEL (MAX) 6·48
EXHAUST LAP. 1/16

APPENDIX L/20. - Horizontal type regulator. — London, Midland and Scottish Railway

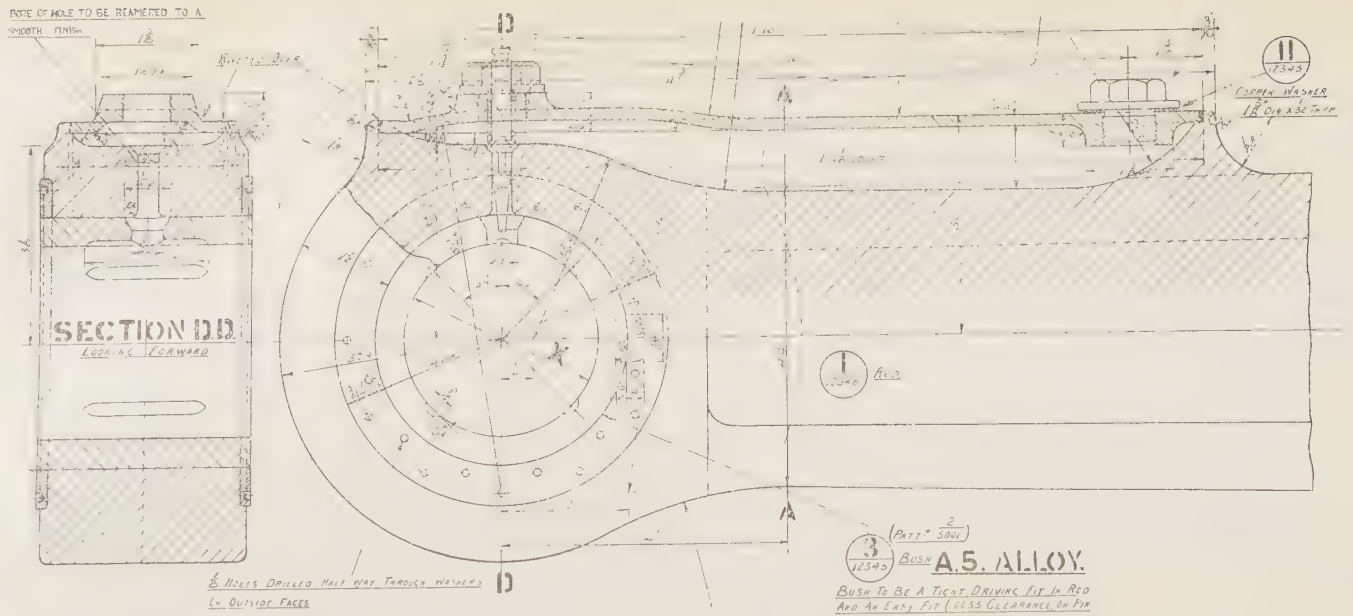


APPENDIX L/21. — Triangular section of wheel rim.

London, Midland and Scottish Railway.



APPENDIX L/22. — Lubrication of little ends. — London, Midland and Scottish Railway.


BORE OF HOLE TO BE REAMERED TO A SMOOTH FINISH
SECTION D.D.
LOOKING FORWARD
6 HOLES DRILLED HALF WAY THROUGH WASHER & ON OUTSIDE FACES
COPPER WASHER
BUSH A.5. ALLOY.
BUSH TO BE A TIGHT DRIVING FIT IN RED AND AN EASY FIT (.0035 CLEARANCE) ON PIN

APPENDIX L/23. — A.4. 4-6-2 streamlined express passenger engine. — London and North Eastern Railway.

RAILWAY L.N.E.

TYPE A.4.
4-6-2 PASSENGER ENGINE

YEAR BUILT 1935.

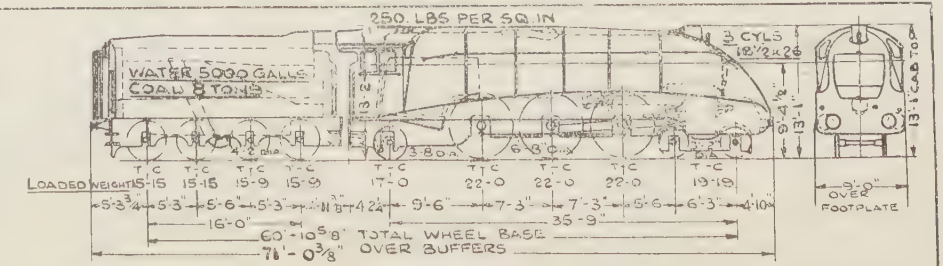
WEIGHTS.

	Engine. T - C.	Tender. T - C	Total. T. - C.
LOADED.	102 - 19	62 - 8	165 - 7.
EMPTY	93 - 1	31 - 11	124 - 12

TOTAL ADHESIVE WEIGHT.
147840 LBS

TRACTIVE EFFORT
@ 85% BOILER PRESSURE 35455 LBS.

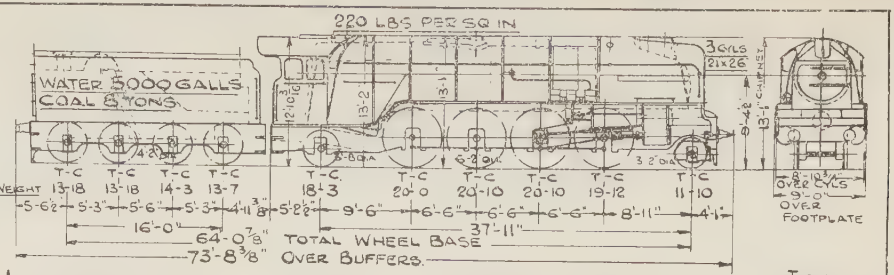
RATIOS
ADHESION FACTOR 4·16
BRAKE % ENGINE & TENDER 79%
RADIUS OF MIN CURVE 6 CHAINS



BOILER BARREL LENGTH 17'-11¾" MAX DIA 6'-5" MIN DIA 5'-9⅜"
FIREBOX (INSIDE) LENGTH 9'-1⅞" WIDTH 6'-1¾" HEIGHT 6'-8⅛"
" VOLUME 274.4 CUB FT
" (OUTSIDE) LENGTH 10'-5¾" WIDTH 7'-9" HEIGHT 8'-10⅞"
TUBES { SUPERHEATER ELEMENTS 43 OUTS DIA 1⅜ 10 SWG; TUBES 43 " " 5⅛ 7/32; SMALL TUBES 121 " " 2⅛ 10 SWG }
DISTANCE BETWEEN TUBEPLATES 17'-11¾"

HEATING SURFACE { TUBES 2345.1 SQ FT; FIREBOX 231.2 " "; SUPERHEAT 748.9 " " } TOTAL EVAPORATIVE 2576.3 SQ FT.
TOTAL 3325.2 " "
GRATE AREA 41.25 " "
MOTION { INSIDE GRESLEY; OUTSIDE WALSCHAERT }
VALVE DIA 9 — TYPE OF VALVE PISTON
STEAM LAP { OUTSIDE 1⅛"; INSIDE 1 11/16" } — VALVE TRAVEL MAX 5¾"
EXHAUST LAP NIL.

RAILWAY. L.N.E.
TYPE. P2. PART 1.
2-8-2 PASSENGER ENGINE
YEAR BUILT. 1934



WEIGHTS.

	ENGINE T-C	TENDER T-C	TOTAL T-2
LOADED	110-5	55-6	165-11
EMPTY	99-14	25-2	124-16

TOTAL ADHESIVE WEIGHT
180.544 LBS.

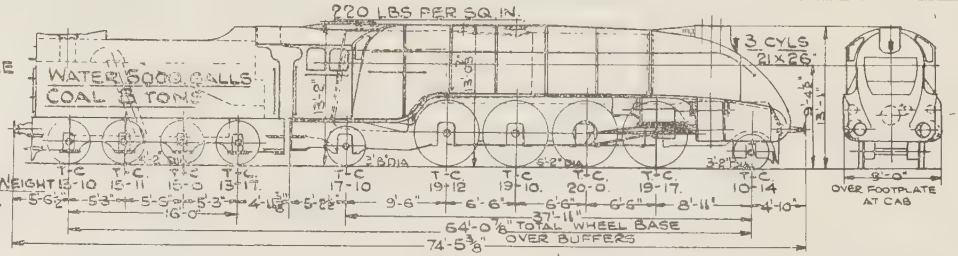
TRACTIVE EFFORT
@ 85% BOILER PRESSURE. 43,462. LBS.

RATIOS
ADHESION FACTOR 4·15
BRAKE % ENGINE & TENDER. 64·2
RADIUS OF MIN. CURVE. 6. CHAINS.

BOILER BARREL LENGTH 19'-0" MAX. DIA. 6'-5" MIN DIA 5'-9 3/16"
FIREBOX (INSIDE) LENGTH 10'-3" WIDTH 6'-11 3/4" HEIGHT 6'-8 13/16"
" VOLUME 296·8 CUB FT
" (OUTSIDE) LENGTH 10'-9" WIDTH 7'-9" HEIGHT 8'-10 1/16"
TUBES SUPERHEATER ELEMENTS. 43 OUTS DIA 1 1/2 10 I.W.G
" TUBES 43 " " 5 1/4 5/32
SMALL TUBES 121 " " 2 1/4 10 I.W.G
DISTANCE BETWEEN TUBEPLATES 18'-11 3/4"

HEATING SURFACE	TUBES	2477 SQ FT	TOTAL EVAPORATIVE 2714 SQ FT
	FIREBOX	237 " "	
	SUPERHEAT	776·5 " "	
	TOTAL	3490·5 " "	
GRATE AREA		50 " "	
MOTION ROTARY CAM		TYPE OF VALVE. POPPET	
VALVE DIA	STEAM 8"		
	EXHAUST 9"		

RAILWAY. L.N.E.
TYPE. P2 STREAMLINED
2-8-2. PASSENGER ENGINE
YEAR BUILT. 1936.



WEIGHTS

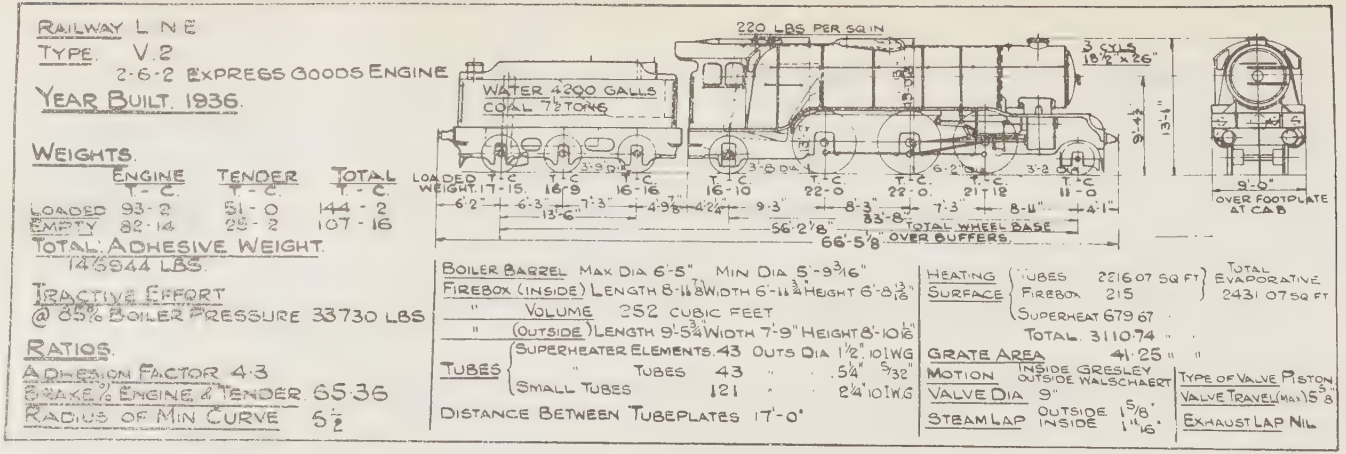
	ENGINE T-C	TENDER T-C	TOTAL T-C
LOADED	107-3	57-18	165-1
EMPTY	96-12.	27-12	124-4

TOTAL ADHESIVE WEIGHT.
176,848. LBS.
TRACTIVE EFFORT
@ 85% BOILER PRESSURE. 43462 LBS
RATIOS.
ADHESION FACTOR 4·06.
BRAKE %. ENGINE & TENDER. 71·5
RADIUS OF MIN. CURVE. 6. CHAINS.

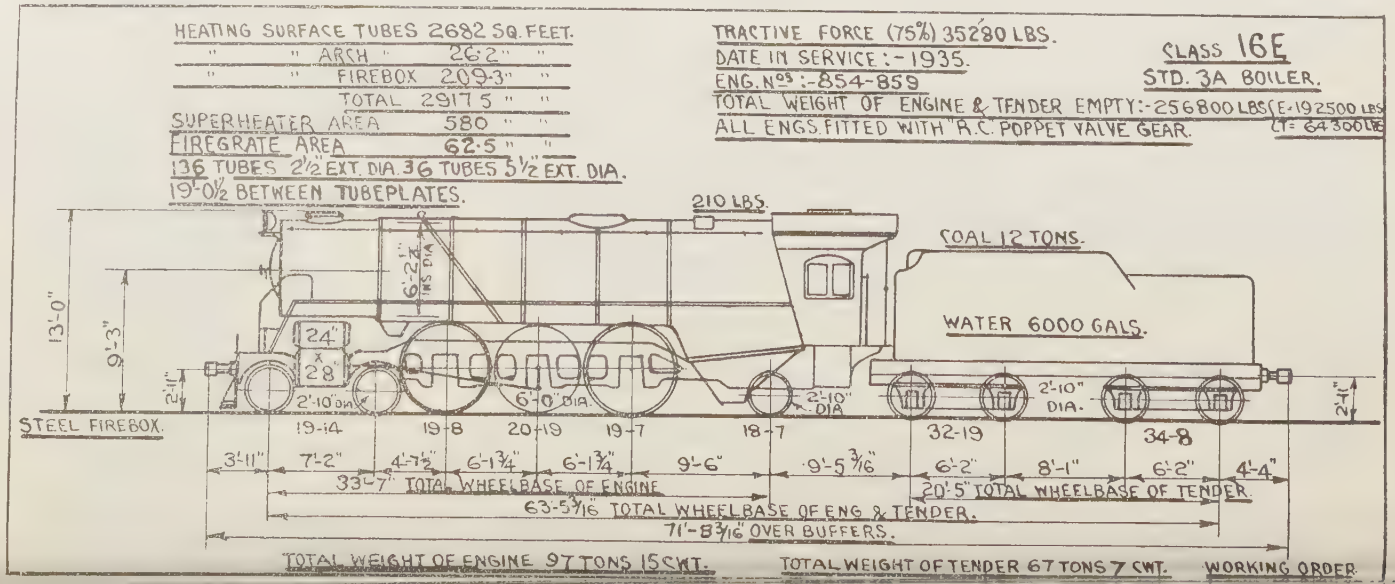
BOILER BARREL. MAX. DIA. 6'-5" MIN DIA 5'-9 3/16"
FIREBOX (INSIDE) LENGTH. 11'-3" WIDTH. 6'-11 3/4" HEIGHT. 6'-8 13/16"
" (VOLUME). 319·2. CUBIC FEET.
" (OUTSIDE). LENGTH. 11'-9" WIDTH. 7'-9" HEIGHT. 8'-10 1/16"
TUBES SUPERHEATER ELEMENTS. 43 OUTS DIA 1 1/2" 10 I.W.G
" TUBES 43 " " 5 1/4" 5/32"
SMALL TUBES 121 " " 2 1/4" 10 I.W.G
DISTANCE BETWEEN TUBEPLATES. 17'-11 3/4"

HEATING SURFACE	TUBES	2345·1 SQ FT	TOTAL EVAPORATIVE 2597·6 SQ FT
	FIREBOX	252·5 " "	
	SUPERHEAT	74·8·9 " "	
	TOTAL	3346·5 " "	
GRATE AREA		50 " "	
MOTION INSIDE OUTSIDE	GRESLEY WALSCHAERT	TYPE OF VALVE PISTON	
VALVE DIA. 9"		VALVE TRAVEL (MAX) 5 5/8"	
STEAM LAP OUTSIDE 1 5/8" INSIDE 1 11/16"		EXHAUST LAP NIL	

APPENDIX L/25. — V. 2, 2-6-2 express passenger and goods engine. — London and North Eastern Railway.


RAILWAY L N E
TYPE. V.2
2-6-2 EXPRESS GOODS ENGINE
YEAR BUILT. 1936.
WEIGHTS.
ENGINE T-C
TENDER T-C
TOTAL T-C
LOADED 93-2 51-0 144-2
EMPTY 82-14 25-2 107-16
TOTAL ADHESIVE WEIGHT. 145944 LBS.
TRACTIVE EFFORT @ 85% BOILER PRESSURE 33730 LBS
RATIOS.
ADHESION FACTOR 4·3
BRAKE % ENGINE & TENDER 65·36
RADIUS OF MIN CURVE 5½
220 LBS PER SQ IN
WATER 4200 GALLS
COAL 7½ TONS
3 CYLS 19½ x 26"
LOADED WEIGHT 17-15 16-9 16-16 16-10 22-0 22-0 21-18 11-0
56-2⅛" TOTAL WHEEL BASE
66-5⅛" OVER BUFFERS.
9'-4"
13'-1"
9'-0" OVER FOOTPLATE AT CAB
BOILER BARREL MAX DIA 6'-5" MIN DIA 5'-9 3/16"
FIREBOX (INSIDE) LENGTH 8-11⅞ WIDTH 6-11¾ HEIGHT 6-8 3/16"
" VOLUME 252 CUBIC FEET
" (OUTSIDE) LENGTH 9'-5¾ WIDTH 7'-9" HEIGHT 8'-10⅛"
TUBES SUPERHEATER ELEMENTS 43 OUTS DIA 1½" 10 SWG
" TUBES 43 " 5¼" 5/32"
SMALL TUBES 121 " 2¼" 10 SWG
DISTANCE BETWEEN TUBEPLATES 17'-0"
HEATING SURFACE TUBES 2216·07 SQ FT
FIREBOX 215
SUPERHEAT 679·67 "
TOTAL EVAPORATIVE 2431·07 SQ FT
TOTAL 3110·74 " "
GRATE AREA 41·25 " "
MOTION INSIDE GRESLEY OUTSIDE WALSCHAERT
VALVE DIA 9"
STEAM LAP OUTSIDE 1 5/8" INSIDE 1 1/16"
TYPE OF VALVE PISTON
VALVE TRAVEL (MAX) 5 5/8"
EXHAUST LAP NIL

APPENDIX L/26. — 16.E, 4-6-2 express passenger engine. — South African Railways.


HEATING SURFACE TUBES 2682 SQ. FEET.
" " ARCH " 26·2 " "
" " FIREBOX 209·3 " "
TOTAL 2917·5 " "
SUPERHEATER AREA 580 " "
FIREGRATE AREA 62·5 " "
136 TUBES 2½ EXT. DIA. 36 TUBES 5½" EXT. DIA.
19'-0½ BETWEEN TUBEPLATES.
TRACTIVE FORCE (75%) 35280 LBS.
DATE IN SERVICE :- 1935.
ENG. Nos :- 854-859
TOTAL WEIGHT OF ENGINE & TENDER EMPTY :- 256800 LBS (E-192500 LBS T= 64300 LBS)
ALL ENGS. FITTED WITH "R.C." POPPET VALVE GEAR.
CLASS 16E
STD. 3A BOILER.
210 LBS.
COAL 12 TONS.
WATER 6000 GALS.
13'-0"
9'-3"
2'-1"
6'-2" DIA
24" x 28"
2'-10" DIA
6'-0" DIA
2'-10" DIA.
2'-1"
STEEL FIREBOX.
19-14 19-8 20-9 19-7 18-7 32-19 34-8
3'-11" 7'-2" 4'-7½" 6'-1¾" 6'-1¾" 9'-6" 9'-5 3/16" 6'-2" 8'-1" 6'-2" 4'-4"
33'-7" TOTAL WHEELBASE OF ENGINE
20'-5" TOTAL WHEELBASE OF TENDER
63-5 3/16 TOTAL WHEELBASE OF ENG & TENDER.
71'-8 3/16" OVER BUFFERS.
TOTAL WEIGHT OF ENGINE 97 TONS 15 CWT.
TOTAL WEIGHT OF TENDER 67 TONS 7 CWT.
WORKING ORDER

RAILWAY GREAT INDIAN PENINSULAR
TYPE XP 5'-6" GAUGE.
4-6-2 PASSENGER ENGINE
YEAR BUILT 1936

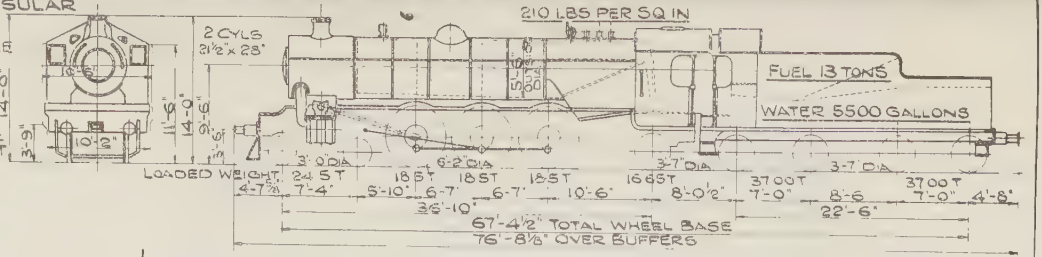
WEIGHTS

	ENGINE	TENDER	TOTAL
LOADED	96·6ST	74·0T	170·6ST

TOTAL ADHESIVE WEIGHT
124,320 LBS

TRACTIVE EFFORT
@ 85% BOILER PRESSURE 31220·6 LBS

RATIOS.
ADHESION FACTOR 3·98


210 LBS PER SQ IN
2 CYLS 21½"×28"
FUEL 13 TONS
WATER 5500 GALLONS
LOADED WEIGHT 24·5T 18·5T 18·5T 18·5T 16·65T 18·00T 18·00T
67'-4½" TOTAL WHEEL BASE
76'-8⅛" OVER BUFFERS

BOILER BARREL LENGTH 19'-8⅝" OUTS DIA 5'-6"

TUBES { SUPERHEATER TUBES 22 OUTS DIA 5½"
SMALL TUBES 95 @ 2¼" DIA, 4@3" DIA
DISTANCE BETWEEN TUBEPLATES 18'-6"

HEATING SURFACE		TOTAL EVAPORATIVE
TUBES	1642 □'	1840 □'
FIREBOX	198 "	
SUPERHEAT	463 "	
TOTAL	2303 "	

GRATE AREA 45 "
MOTION CAPROTTI

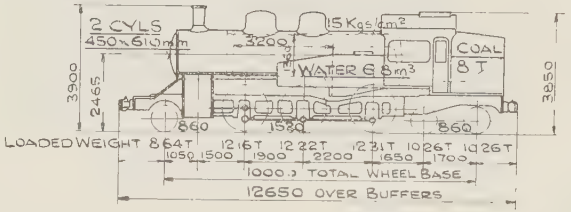
APPENDIX L/28. — C11, 2-6-4 passenger tank engine. — Japanese Government Railways.

RAILWAY JAPANESE GOVERNMENT.
TYPE C 11
2-6-4 SUPERHEATED TANK ENGINE
YEAR BUILT 1933.

WEIGHTS

LOADED	65·85 T
EMPTY	51·69 T

TOTAL ADHESIVE WEIGHT
36690 Kgs



BOILER BARREL 1360 mm DIA

TUBES { SUPERHEATER ELEMENTS 24
" TUBES 24 DIA 127 mm
SMALL TUBES 87 DIA 45 mm
DISTANCE BETWEEN TUBEPLATES 3200 mm

HEATING SURFACE		TOTAL EVAPORATIVE
TUBES	643 m²	743 m²
FIREBOX	100 "	
SUPERHEAT	29·8 "	
TOTAL	104·1 "	

GRATE AREA 1·6 m²
MOTION WALSCHAERT

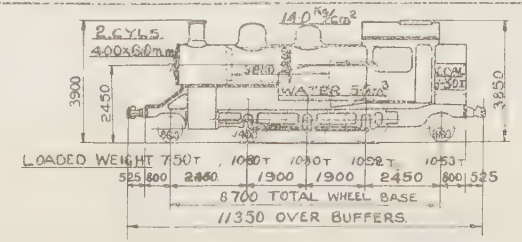
APPENDIX L/29. — C12, 2-6-2 passenger tank engine. — Japanese Government Railways.

RAILWAY JAPANESE GOVERNMENT RAILWAY.
TYPE C.12.
2-6-2. SUPERHEATED TANK ENGINE
YEAR BUILT 1933

WEIGHTS

	ENGINE
LOADED	50·05 T
EMPTY	39·54 T

TOTAL ADHESIVE WEIGHT
32020 Kgs.



BOILER BARREL 1200 m.m DIA

TUBES { SUPERHEATER ELEMENTS 16
" TUBES 16 DIA 127m m
SMALL TUBES 68 DIA 45m m.

DISTANCE BETWEEN TUBEPLATES 3200 m.m.

HEATING SURFACE { TUBES 47·0 m² / FIREBOX 7·4 m² / SUPERHEAT 19·8 m² } TOTAL EVAPORATIVE 54·4 m²
TOTAL 74·2 m²

GRATE AREA 1·30 m²
MOTION WALSCHAERT

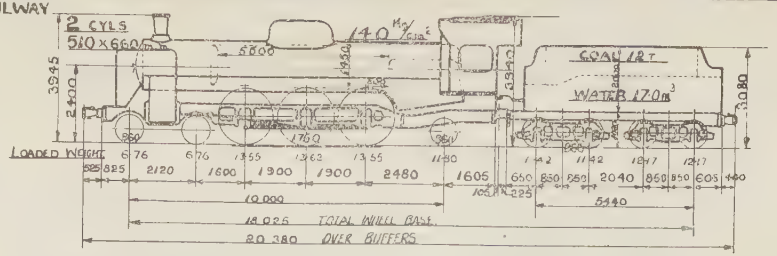
Japanese Government Railways.

RAILWAY JAPANESE GOVERNMENT RAILWAY
TYPE C 55
4-6-2 PASSENGER ENGINE.
YEAR BUILT. 1935.

WEIGHTS

	ENGINE.	TENDER	TOTAL
LOADED	66·04T.	47·18T.	113·22T
EMPTY	59·42T.	18·18T.	77·60T.

TOTAL ADHESIVE WEIGHT
40,720 Kgs.



BOILER BARREL 1450 m m DIA

TUBES { SUPERHEATER ELEMENTS. 18.
" TUBES 18 DIA 140m/m
SMALL TUBES. 84 DIA 57m/m

DISTANCE BETWEEN TUBEPLATES 5500m/m

HEATING SURFACE { TUBES. 116 m² / FIREBOX. 11·4m² / SUPERHEAT. 41·4m² / TOTAL 167·8m² } TOTAL EVAPORATIVE. 127·4m²

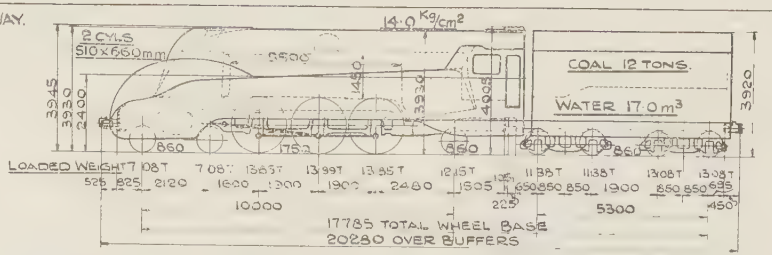
GRATE AREA 2·53m²
MOTION WALSCHAERT

RAILWAY JAPANESE GOVERNMENT RAILWAY.
TYPE C 55 STREAMLINED
4-6-2 PASSENGER ENGINE
YEAR BUILT 1935.

WEIGHTS

	ENGINE.	TENDER	TOTAL
LOADED	68·00T	48·92T	116·92T
EMPTY	61·60T	19·92T	81·52T

TOTAL ADHESIVE WEIGHT
41690 Kgs.



BOILER BARREL 1450mm DIA

TUBES { SUPERHEATER ELEMENTS 18 / " TUBES 18 DIA 140mm / SMALL TUBES. 84 DIA 57mm

DISTANCE BETWEEN TUBEPLATES 5500mm

HEATING SURFACE { TUBES 116·0m² / FIREBOX 11·4 " / SUPERHEAT 41·4 " / TOTAL 168·8 " } TOTAL EVAPORATIVE 127·4 m²

GRATE AREA 2·53m²
MOTION WALSCHAERT

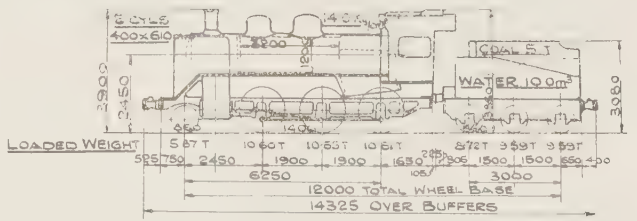
APPENDIX L/31. — C.56, 2-6-0 heavy freight engine. — Japanese Government Railways.

RAILWAY JAPANESE GOVERNMENT
TYPE C 56
2-6-0 ENGINE
YEAR BUILT 1935

WEIGHTS

	ENGINE	TENDER	TOTAL
LOADED	37.63 T	27.90 T	65.53 T
EMPTY	34.27 T	12.90 T	47.17 T

TOTAL ADHESIVE WEIGHT
31760 Kgs



BOILER BARREL 1200 mm DIA

TUBES { SUPERHEATER ELEMENTS 16
" TUBES 16 DIA 127mm.
SMALL TUBES 68 DIA 45mm

DISTANCE BETWEEN TUBEPLATES 3200 mm

HEATING SURFACE { TUBES 47.0 m² / FIREBOX 7.4 " / SUPERHEAT 19.8 " / TOTAL 74.2 " } TOTAL EVAPORATIVE 54.4 m²

GRATE AREA 1.3 "
MOTION WALSCHAERT

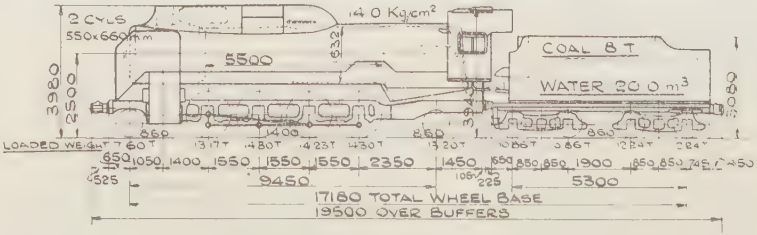
APPENDIX L/32. - - D.51, 2-8-2 branch passenger (tender) engine. — Japanese Government Railways.

RAILWAY JAPANESE GOVERNMENT
TYPE D 51
2-8-2 PASSENGER ENGINE
YEAR BUILT 1936

WEIGHTS

	ENGINE	TENDER	TOTAL
LOADED	76.80 T	46.20 T	123.00 T
EMPTY	68.50 T	18.20 T	86.70 T

TOTAL ADHESIVE WEIGHT
56000 Kgs.



BOILER BARREL 1632 mm DIA

TUBES { SUPERHEATER ELEMENTS 28
" TUBES 28 DIA 140mm
SMALL TUBES 90 DIA 57mm

DISTANCE BETWEEN TUBEPLATES 5500 mm

HEATING SURFACE { TUBES 144.4 m² / FIREBOX 12.7 " / SUPERHEAT 64.4 " / TOTAL 221.5 " } TOTAL EVAPORATIVE 157.1 m²

GRATE AREA 3.3 "
MOTION WALSCHAERT

APPENDIX L/33. — Results of dynamometer car tests of new 2-6-6-2 and 4-8-2 engines.
Baltimore and Ohio Railroad.

Tests in slow freight train service on east end of Cumberland Division
January to April, 1931.

		7 400 KK-1		7 450 KK-2		5 510 T-1	
Locomotive number							
Class							
Direction		East	West	East	West	East	West
Speeds attained, m. p. h.		40		42		40	
Average weight of train (*), tons		8 245	2 832	8 156	2 774	5 669	2 111
Drawbar pull in pounds.	Average	47 951	42 358	48 340	42 036	30 839	30 001
	Maximum	86 000		88 000		62 000	
Average drawbar horsepower		2 546	2 483	2 593	2 459	1 863	1 880
Average steam temperature in degrees F.	Not taken at header	—	—	—	—	—	—
	At steam chest	554.9	563.8	580.4	609.7	553.4	571.3
	At exhaust	255.6	248.6	263.5	262.3	246.3	251.4
Average steam pressure in lb./sq. in.	In boiler	246.2	245.4	240.7	240.9	244.5	242.8
	At steam chest (**)	216.3	211.3	200.7	194.0	221.9	221.5
	At exhaust	3.7	4.1	4.8	5.2	6.7	7.2
Pounds per 100 ton (*)-miles.	Coal consumed	3.51	11.35	3.88	12.22	3.51	10.69
	Water from tank	24.16	73.59	24.02	73.85	23.89	72.21
	Water evaporated (***)	26.30	80.63	25.87	79.79	25.77	78.37

(*) Not including locomotive.
(**) Includes running at partial throttle opening.
(***) Exhaust feed water heater injector used on tests tabulated.

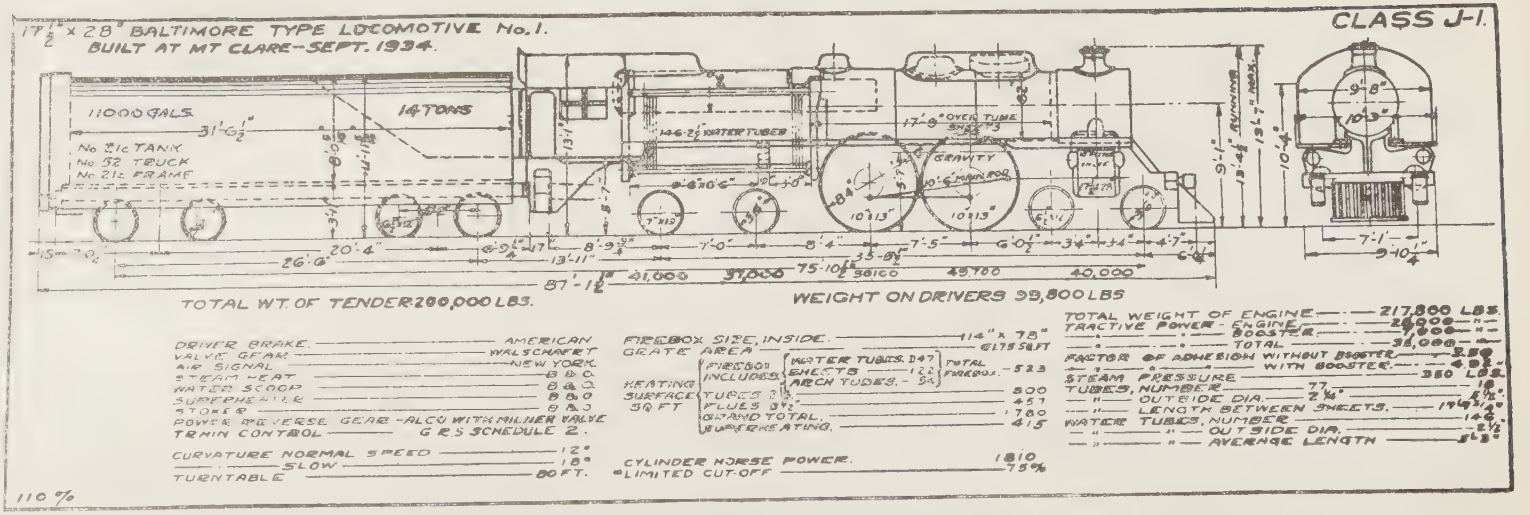
Locomotive No. 7400 was also tested in fast freight train service between Jersey City and Chicago in February and March, 1932. Fuel and water consumptions were not taken on these tests. Speeds up to 65 m.p.h. were attained. At 4 m.p.h. drawbar pull of 87 000 pounds was available on level tangent track, and 3 900 drawbar horse-power sustained between 45 and 50 m.p.h.

APPENDIX L/34. — Results of dynamometer car tests of five new types of engines (express passenger and freight).
London, Midland and Scottish Railway.

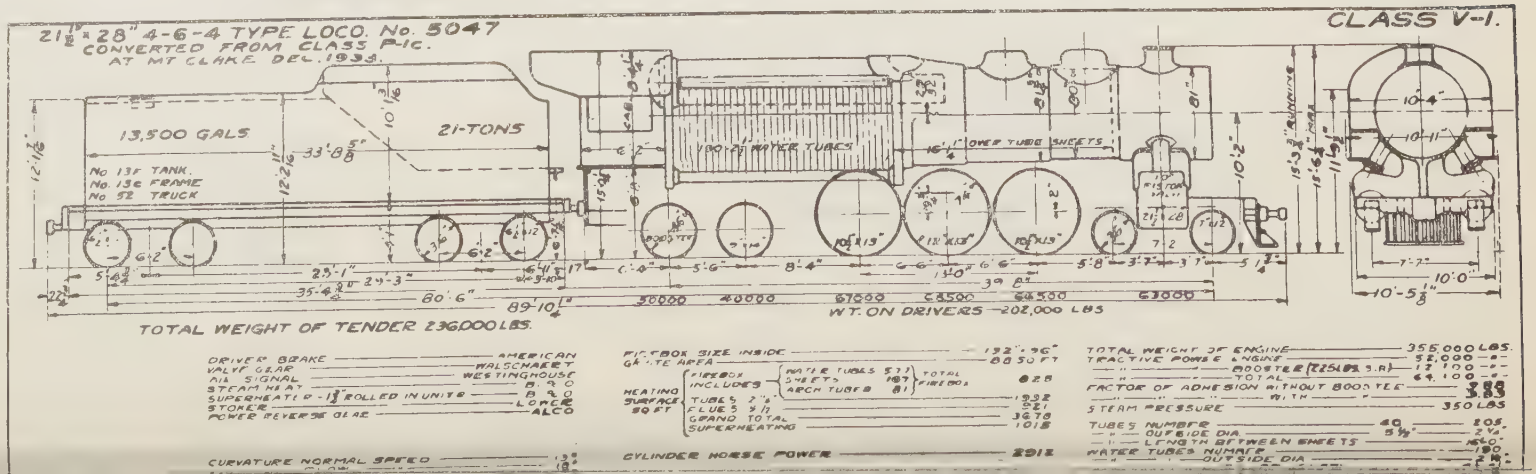
	4-6-2	3 cyl. 5x. 4-6-0	2-cyl. 4-6-0 on passenger train.	2-cyl. 4-6-0 on fast freight train.	2-cyl. 2-6-0 on fast freight train.	2-8-0 2-6-4 2-6-2
Speeds attained (m.p.h.):						
Maximum	82	82	80	70	68	
Average	53	58	51.5	34	33	
Weight of train (tons)	575	350	450	550	495	
Drawbar pull (tons):						
At 10 m.p.h.	11.5	6.8	8.0	8.0	8.4	
At 60 m.p.h.	4.9	2.3	2.3	2.3	—	
At 55 m.p.h.	—	—	—	—	2.4	
Drawbar horse-power:						
Maximum: Sustained	1 647	1 100	948	948	912	
Fuel and water consumption:						
Lb. coal per D.H.P.H.	2.92	3.34	2.95	3.89	3.54	
Lb. water per D.H.P.H.	25.6	25.5	22.5	29.9	27.1	
Evaporation:						
Lb. water per lb. coal	8.76	7.56	7.56	7.7	7.7	
Steam temperatures at:						
Steam chest, °F.	580	580				
(Temperatures at header and exhaust not taken.)						
Steam pressures in:						
Boiler, lb./sq. in.	250	225	225	225	225	
Steam chest, lb./sq. in.	245	210	212	212	—	
Exhaust, lb./sq. in.	6	6	6	6	—	

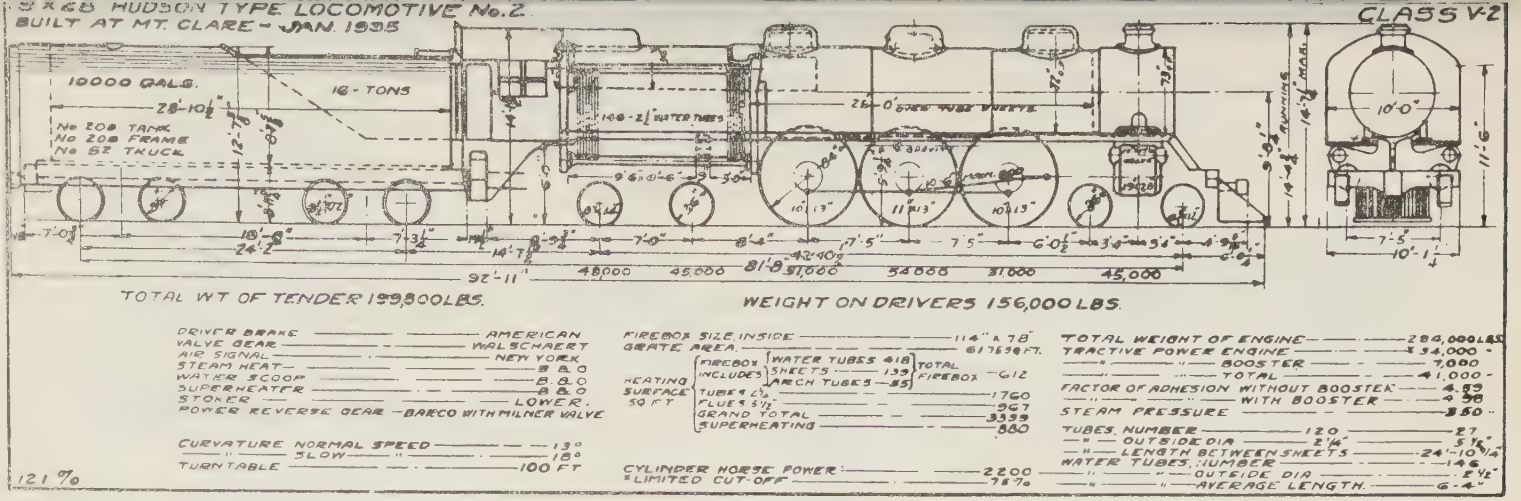
Figures not available.

APPENDIX M/1. — **J1, 4-4-4 express passenger engine.** — Baltimore and Ohio Railroad.

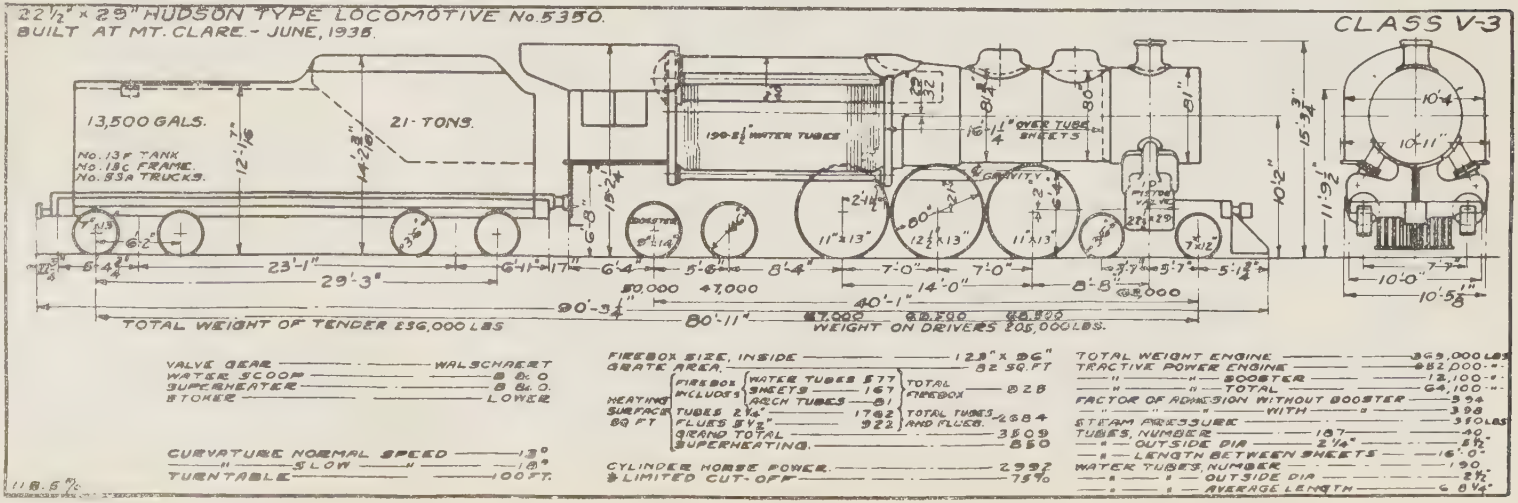

17½" x 28" BALTIMORE TYPE LOCOMOTIVE No. 1.
BUILT AT MT CLARE-SEPT. 1934.
CLASS J-1.
11000 GALS.
14 TONS
No 21c TANK
No 52 TRUCK
No 21c FRAME
146-2½" WATER TUBES
17'-9" OVER TUBE SHEETS
GRAVITY
TOTAL WT. OF TENDER 200,000 LBS.
WEIGHT ON DRIVERS 99,800 LBS
DRIVER BRAKE — AMERICAN
VALVE GEAR — WALSCHAERT
AIR SIGNAL — NEW YORK
STEAM HEAT — B & O
WATER SCOOP — B & O
SUPERHEATER — B & O
STOKER — B & O
POWER REVERSE GEAR - ALCO WITH MILNER VALVE
TRAIN CONTROL — G.R.S. SCHEDULE 2.
CURVATURE NORMAL SPEED — 12°
SLOW — 18°
TURNTABLE — 80 FT.
FIREBOX SIZE, INSIDE — 114" x 78"
GRATE AREA — 61.75 SQ FT
HEATING SURFACE SQ FT
FIREBOX INCLUDES: WATER TUBES 247, SHEETS 122, ARCH TUBES 54 — TOTAL FIREBOX 523
TUBES 3½" — 500
FLUES 5½" — 457
GRAND TOTAL — 1780
SUPERHEATING — 415
CYLINDER HORSE POWER — 1810
*LIMITED CUT-OFF — 75%
TOTAL WEIGHT OF ENGINE — 217,800 LBS.
TRACTIVE POWER - ENGINE — 25,000 "
BOOSTER — 7,000 "
TOTAL — 32,000 "
FACTOR OF ADHESION WITHOUT BOOSTER — 3.89
WITH BOOSTER — 4.81
STEAM PRESSURE — 250 LBS.
TUBES, NUMBER — 77 — 18
OUTSIDE DIA. — 2¼" — 5½"
LENGTH BETWEEN SHEETS — 17'-4"
WATER TUBES, NUMBER — 146
OUT SIDE DIA. — 2½"
AVERAGE LENGTH — 21'-3"
110 %

APPENDIX M/2. — **V1, 4-6-4 heavy passenger train engine.** — Baltimore and Ohio Railroad.

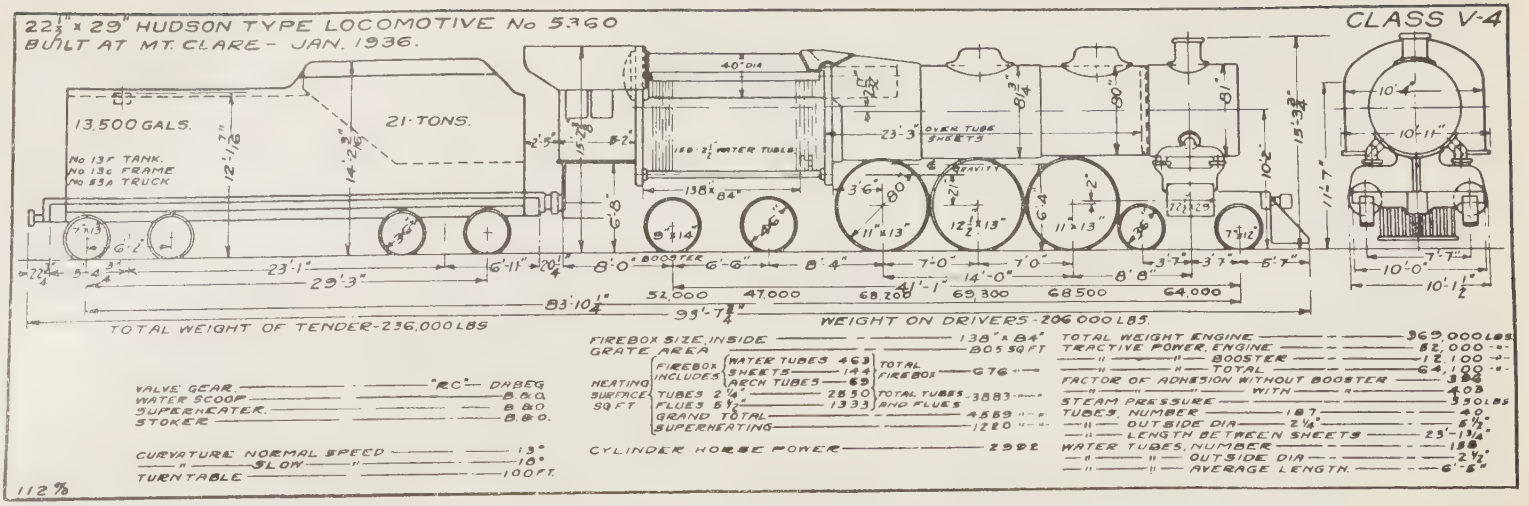

21½" x 28" 4-6-4 TYPE LOCO. No. 5047
CONVERTED FROM CLASS P-1c.
AT MT CLARE DEC. 1935.
CLASS V-1.
13,500 GALS
21-TONS
No 13f TANK.
No. 13e FRAME
No 52 TRUCK
180 2¼" FIRE TUBES
16'-1" OVER TUBE SHEETS
TOTAL WEIGHT OF TENDER 236,000 LBS.
WT. ON DRIVERS — 202,000 LBS
DRIVER BRAKE — AMERICAN
VALVE GEAR — WALSCHAERT
AIR SIGNAL — WESTINGHOUSE
STEAM HEAT — B. & O.
SUPERHEATER - 1½" ROLLED IN UNITS — B & O
STOKER — LOCO
POWER REVERSE GEAR — ALCO
CURVATURE NORMAL SPEED — 13°
SLOW — 18°
FIREBOX SIZE INSIDE — 132" x 96"
GRATE AREA — 88.50 SQ FT
HEATING SURFACE SQ FT
FIREBOX INCLUDES: WATER TUBES 511, SHEETS 187, ARCH TUBES 81 — TOTAL FIREBOX 828
TUBES 2 ¼" — 1932
FLUES 5 ½" — 521
GRAND TOTAL — 3478
SUPERHEATING — 1018
CYLINDER HORSE POWER — 2912
TOTAL WEIGHT OF ENGINE — 355,000 LBS.
TRACTIVE POWER - ENGINE — 52,000 "
BOOSTER (2 AXLES) — 12,100 "
TOTAL — 64,100 "
FACTOR OF ADHESION WITHOUT BOOSTER — 3.89
WITH — 4.71
STEAM PRESSURE — 350 LBS
TUBES NUMBER — 40 — 205
OUTSIDE DIA. — 5½" — 2¼"
LENGTH BETWEEN SHEETS — 16'-0"
WATER TUBES NUMBER — 190
OUTSIDE DIA. — 2½"


CLASS V-2
10000 GALS.
16 - TONS
TOTAL WT OF TENDER 199,800 LBS.
WEIGHT ON DRIVERS 156,000 LBS.
DRIVER BRAKE — AMERICAN
VALVE GEAR — WALSCHAERT
AIR SIGNAL — NEW YORK
STEAM HEAT — B & O
WATER SCOOP — B. & O.
SUPERHEATER — B & O
STOKER — LOWER
POWER REVERSE GEAR — BARCO WITH MILNER VALVE
CURVATURE NORMAL SPEED — 13°
" SLOW " 18°
TURNTABLE — 100 FT
121 %
FIREBOX SIZE INSIDE — 114" x 78"
GRATE AREA — 61.56 SQ. FT.
HEATING SURFACE 50 FT
FIREBOX INCLUDES WATER TUBES 418 SHEETS 133 ARCH TUBES 85 TOTAL FIREBOX 612
TUBES 2¼" — 1760
FLUES 5½" — 967
GRAND TOTAL — 3339
SUPERHEATING — 880
CYLINDER HORSE POWER — 2200
% LIMITED CUT-OFF — 75%
TOTAL WEIGHT OF ENGINE — 284,000 LBS
TRACTIVE POWER ENGINE — 54,000
" BOOSTER — 7,000
" TOTAL — 61,000
FACTOR OF ADHESION WITHOUT BOOSTER — 4.83
" WITH BOOSTER — 4.38
STEAM PRESSURE — 250
TUBES, NUMBER — 121
" OUTSIDE DIA — 2¼" — 5½"
" LENGTH BETWEEN SHEETS — 24'-10¼"
WATER TUBES, NUMBER — 146
" OUTSIDE DIA — 2½"
" AVERAGE LENGTH — 6'-4"

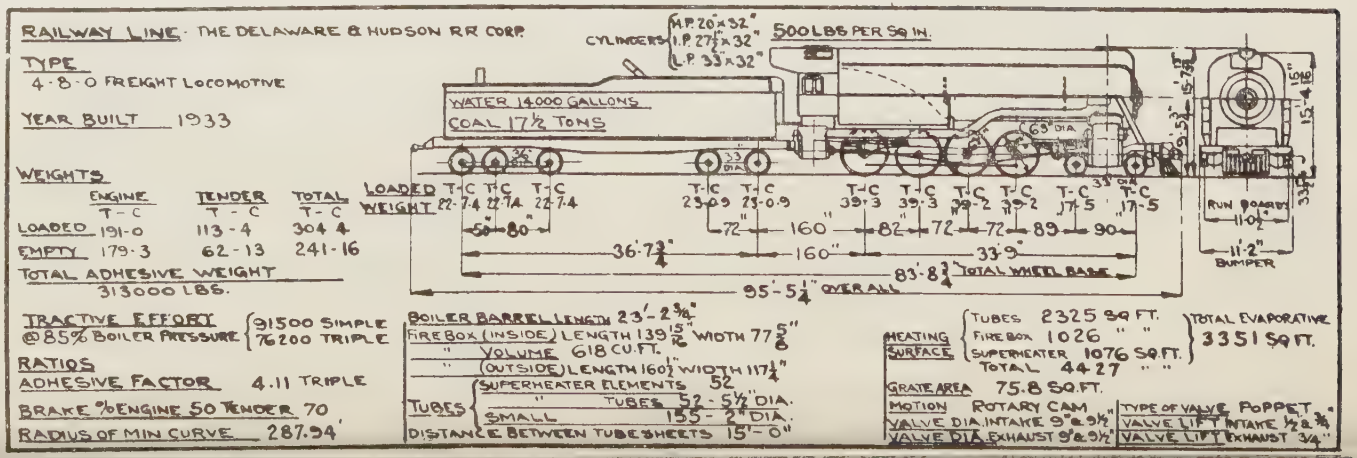
APPENDIX M 4. V3, 4-6-4 heavy passenger train engine. — Baltimore and Ohio Railroad.


CLASS V-3
13,500 GALS.
21 - TONS.
TOTAL WEIGHT OF TENDER 236,000 LBS
WEIGHT ON DRIVERS 205,000 LBS.
VALVE GEAR — WALSCHAERT
WATER SCOOP — B & O
SUPERHEATER — B & O.
STOKER — LOWER
CURVATURE NORMAL SPEED — 13°
" SLOW " 18°
TURNTABLE — 100 FT.
118.5%
FIREBOX SIZE, INSIDE — 128" x 96"
GRATE AREA — 82.96 FT
HEATING SURFACE 50 FT
FIREBOX INCLUDES WATER TUBES 577 SHEETS 167 ARCH TUBES 81 TOTAL FIREBOX 825
TUBES 2¼" — 1782
FLUES 5½" — 922
TOTAL TUBES AND FLUES 2704
GRAND TOTAL — 3509
SUPERHEATING — 850
CYLINDER HORSE POWER — 2997
% LIMITED CUT-OFF — 75%
TOTAL WEIGHT ENGINE — 369,000 LBS
TRACTIVE POWER ENGINE — 82,000
" BOOSTER — 13,100
" TOTAL — 94,100
FACTOR OF ADHESION WITHOUT BOOSTER — 3.94
" WITH " — 3.58
STEAM PRESSURE — 310 LBS
TUBES, NUMBER — 187 — 40
" OUTSIDE DIA — 2¼" — 5½"
" LENGTH BETWEEN SHEETS — 16'-0"
WATER TUBES, NUMBER — 190
" OUTSIDE DIA — 2½"
" AVERAGE LENGTH — 6 8¼"

APPENDIX M/5. — V4. 4-6-4 heavy passenger train engine. — Baltimore and Ohio Railroad.



APPENDIX M/6. — 4-8-0 freight engine, « J. T. Loree ». — Delaware and Hudson Company.


RAILWAY LINE. THE DELAWARE & HUDSON RR CORP.
TYPE
4-8-0 FREIGHT LOCOMOTIVE
YEAR BUILT 1933
WEIGHTS
ENGINE T-C
TENDER T-C
TOTAL T-C
LOADED 191-0 113-4 304 4
EMPTY 179-3 62-13 241-16
TOTAL ADHESIVE WEIGHT 313000 LBS.
TRACTIVE EFFORT @85% BOILER PRESSURE 91500 SIMPLE 76200 TRIPLE
RATIOS
ADHESIVE FACTOR 4.11 TRIPLE
BRAKE %ENGINE 50 TENDER 70
RADIUS OF MIN CURVE 287.94'
CYLINDERS H.P. 20"x32" I.P. 27½"x32" L.P. 33"x32" 500 LBS PER SQ IN.
WATER 14000 GALLONS
COAL 17½ TONS
LOADED WEIGHT
95'-5¼" OVERALL
83'-8¾" TOTAL WHEEL BASE
BOILER BARREL LENGTH 23'-2⅜"
FIREBOX (INSIDE) LENGTH 139 15/16" WIDTH 77 5/8"
VOLUME 618 CU.FT.
(OUTSIDE) LENGTH 160½" WIDTH 117¼"
TUBES SUPERHEATER ELEMENTS 52
TUBES 52 - 5½" DIA.
SMALL 155 - 2" DIA.
DISTANCE BETWEEN TUBESHEETS 15'-0"
HEATING SURFACE TUBES 2325 SQ FT.
FIREBOX 1026 " "
SUPERHEATER 1076 SQ FT.
TOTAL 4427 " "
TOTAL EVAPORATIVE 3351 SQ FT.
GRATE AREA 75.8 SQ.FT.
MOTION ROTARY CAM
VALVE DIA. INTAKE 9"&9½"
VALVE DIA. EXHAUST 9"&9½"
TYPE OF VALVE POPPET
VALVE LIFT INTAKE ½ & ¾"
VALVE LIFT EXHAUST ¾"
RUN POSITION
BUMPER

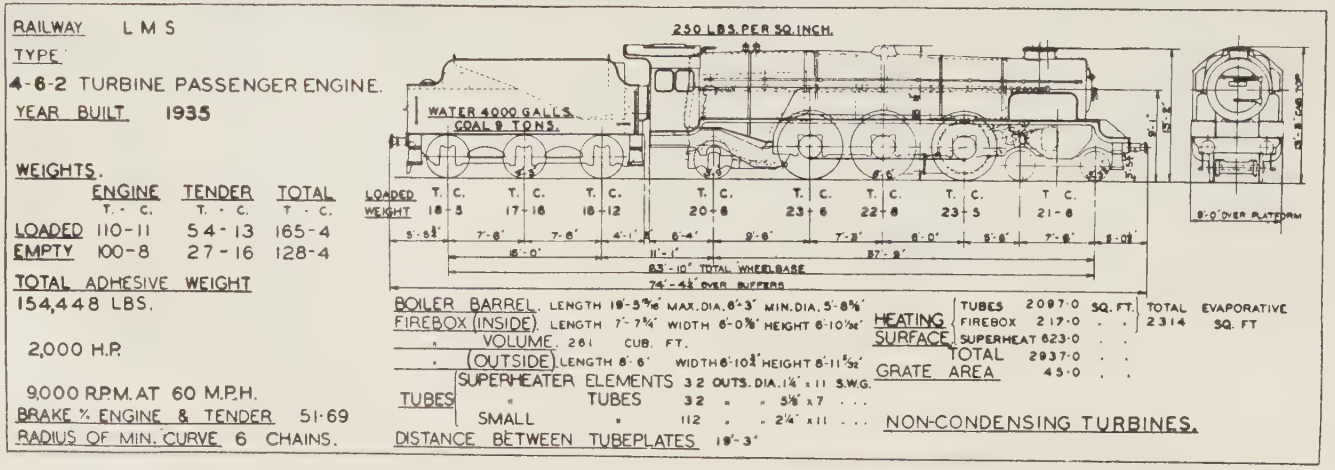
APPENDIX M/7. — Results obtained from test with V.3 locomotive in ordinary train working.
Baltimore and Ohio Railroad.

Test of locomotive No. 5350, in regular passenger train service from Washington D.C. to Chicago, Ill., in September, 1935 :

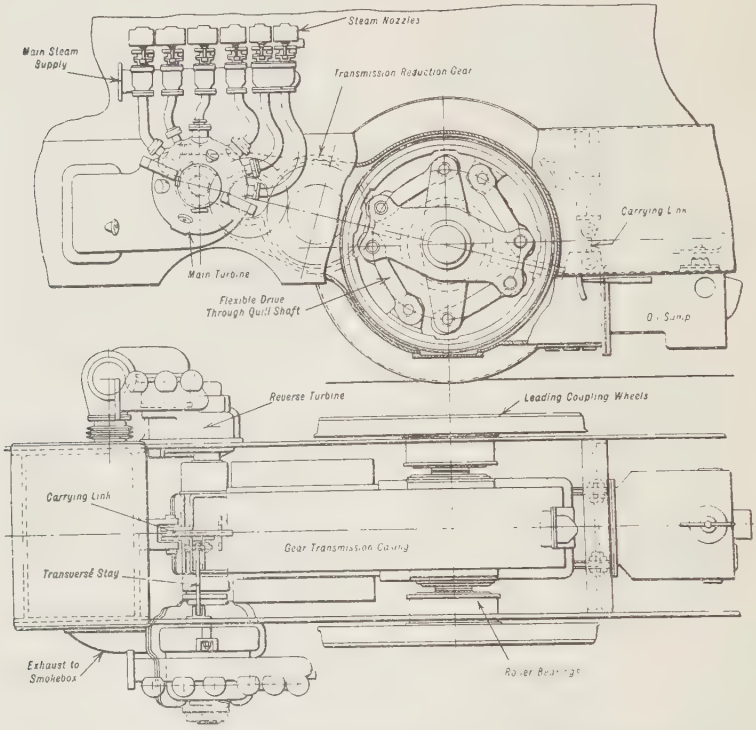
Speed attained, m.p.h.	73	At header and exhaust	Not taken.
Average weight of train (1) tons	942	Average steam pressure in lb. per sq. in.	
Drawbar pull in pounds — Average	10 499	In boiler	337.0
Drawbar pull in pounds — Maximum	42 000	At steam chest (2)	307.0
Average drawbar horse-power	1 449	Exhaust	6.8
Average steam temperature, in degrees F.		Coal consumed, lb. per 100 ton-miles (1)	11.56
At steam chest	600.6	Water evaporated, do.	82.92

(1) Not including locomotive.
(2) Includes running at partial throttle opening.
(3) Boiler fed by live steam injector.

APPENDIX N/1. — Non-condensing turbine passenger engine. — London, Midland and Scottish Railway.


RAILWAY L M S
TYPE
4-6-2 TURBINE PASSENGER ENGINE.
YEAR BUILT 1935
WEIGHTS.
ENGINE TENDER TOTAL
LOADED 110-11 54-13 165-4
EMPTY 100-8 27-16 128-4
TOTAL ADHESIVE WEIGHT
154,448 LBS.
2,000 H.P.
9,000 R.P.M. AT 60 M.P.H.
BRAKE % ENGINE & TENDER 51·69
RADIUS OF MIN. CURVE 6 CHAINS.
250 LBS. PER SQ. INCH.
WATER 4000 GALLS.
COAL 9 TONS.
LOADED WEIGHT 18-5 17-16 18-12 20-8 23-6 22-8 23-5 21-8
9'-0" OVER PLATFORM
63'-10" TOTAL WHEEL BASE
74'-4½" OVER BUFFERS
BOILER BARREL. LENGTH 19'-5⅝" MAX. DIA. 6'-3" MIN. DIA. 5'-8⅝"
FIREBOX (INSIDE). LENGTH 7'-7¾" WIDTH 6'-0⅜" HEIGHT 6'-10⅞"
VOLUME. 261 CUB. FT.
(OUTSIDE) LENGTH 8'-6" WIDTH 6'-10¼" HEIGHT 6'-11⅝"
SUPERHEATER ELEMENTS 32 OUTS. DIA. 1¼" x 11 S.W.G.
TUBES TUBES 32 " " 5⅛" x 7 " "
SMALL " 112 " " 2¼" x 11 " "
DISTANCE BETWEEN TUBEPLATES 19'-3"
HEATING SURFACE — TUBES 2097·0 SQ. FT. FIREBOX 217·0 " " SUPERHEAT 623·0 " " TOTAL 2937·0 " "
TOTAL EVAPORATIVE 2314 SQ. FT
GRATE AREA 45·0 " "
NON-CONDENSING TURBINES.

APPENDIX N/2. — General arrangement of turbine and reduction gearing. London, Midland and Scottish Railway.



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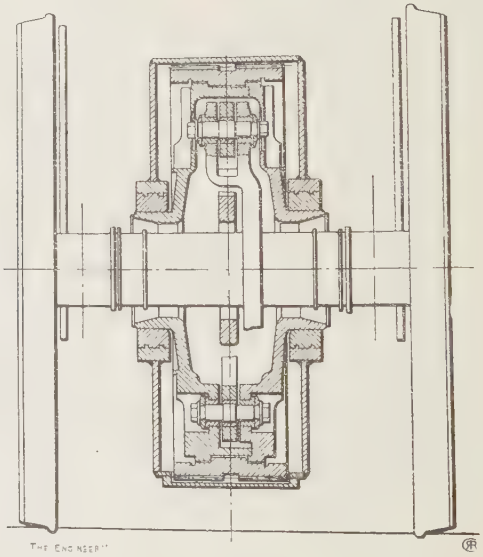
APPENDIX N/3.— Quill drive on leading axle. — London, Midland and Scottish Railway.



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PART THREE.

Tests of locomotives on testing plants and on the line.

APPENDICES TO PART THREE.

Appendix number.	Detail.	Particulars.	Administration.	Chapter number.	Question number.
P/1	Diagram.	Boiler efficiency testing plant.	Baltimore and Ohio.	15	1
P/2	Drawing.	Longitudinal section of Altoona test plant.	Pennsylvania.	15	2
P/3	Drawing.	Cross-section of Altoona test plant.	Pennsylvania.	15	2
P/4	Drawing.	Longitudinal section of Swindon test plant.	Great Western.	15	2
P/5	Drawing.	Plan of Swindon test plant.	Great Western.	15	2
P/6	Drawing.	Side elevation and plan of Oi test plant.	Japanese Government.	15	2
P/7	Photograph.	Arrangement of Oi test plant with engine in position.	Japanese Government.	15	2
P/8	Drawing.	Arrangement of « Alden » friction brake (three revolving elements).	Pennsylvania.	15	3
P/9	Photograph.	Alternative method of setting engine wheel on brake roller.	Pennsylvania.	15	3
P/10	Drawing.	Arrangement of water-cooled friction brake.	Great Western.	15	3
P/11	Drawing.	Arrangement of « Alden » friction brake (two revolving elements).	Japanese Government.	15	3
P/12	Diagram.	Method of setting engine wheel on brake roller.	Japanese Government.	15	3
P/13	Drawing.	Weighing type lever dynamometer.	Pennsylvania.	15	4
Q/1	Diagram.	Location of pyrometers in firebox.	Pennsylvania.	16	1
Q/2	Diagram.	Location of connections for measuring temperature in steam and exhaust passages and back pressure.	Pennsylvania.	16	1
Q/3	Diagram.	Location of thermo-couples for measuring temperature of exhaust steam.	Pennsylvania.	16	1
Q/4	Diagram.	Location of thermometer and gas sampling tubes in smokebox.	Pennsylvania.	16	1
Q/5 Q/6 Q/7 Q/8 Q/9 Q/10	Tables.	Forms used in the calculation of the heat balance for the boiler, with typical results.	Pennsylvania.	16	4

Appendix number.	Detail.	Particulars.	Administration.	Chapter number.	Question number.
Q/11 Q/12 Q/13 Q/14	Tables.	Forms used in the calculation of the heat balance for the boiler, with typical results.	Japanese Government.	16	4
R/1	Photograph.	Plan view of dynamometer car underframe shewing instrument table and push and pull springs.	London, Midland and Scottish.	17	2
R/2	Diagram.	Plan of lay-out in dynamometer car.	London and North Eastern.	17	2
R/3	Diagram.	Plan of lay-out and end and side elevations of new dynamometer car under construction.	Japanese Government.	17	2
S/1	Diagram.	4-6-0 brake locomotive, with lay-out of steam and water pipes.	London and North Eastern.	18	1
T/0	Chart.	Dynamometer car records of tests with express passenger Engine No. 3923.	Buenos Ayres Great Southern.	19	4
T/1	Graph.	Characteristic curve (drawbar pull and horse-power) for V. 3 class engine No. 5350.	Baltimore and Ohio.	19	4
T/2	Table.	Performance (including indicating data) of V-3, 4-6-4 type engine, No. 5350.	Baltimore and Ohio.	19	4
T/3	Table.	Full consumption test of engine No. 5350.	Baltimore and Ohio.	19	4
T/4	Graph.	Characteristic curves of drawbar pull and speed for four-cylinder 4-6-0 « Castle » class engine.	Great Western.	19	4
T/5	Chart.	Curves indicating performance obtained on test with «Castle» class engine.	Great Western.	19	4
T/6	Table.	Particulars of information taken during power and consumption trials.	London, Midland and Scottish.	19	4
T/6(1)	Table.	Particulars of information taken during power and consumption trials.	London and North Eastern.	19	4
T/7	Statement.	Brief summary of types of test made.	London, Midland and Scottish.	19	4
T/7(1)	Statement.	Brief summary of types of test made.	London and North Eastern.	19	4
T/8	Chart.	Performance of *Pacific* engine with 400-ton train on heavy gradients.	London and North Eastern.	19	4

pendix mber.	Detail.	Particulars.	Administration.	Chapter number.	Question number.
[/9	Graph.	Cylinder performance at varying speeds and cut-offs, D.4 engine, Caprotti valve gear.	Great Indian Peninsula.	19	4
[/10	Graph.	Cylinder performance at varying speeds and cut-offs, D.5 engine, Walschaerts valve gear.	Great Indian Peninsula.	19	4
[/11	Graph.	Cylinder performance at varying speeds and cut-offs, E.I.Rly. engine No. 252.	Great Indian Peninsula.	19	4
[/12	Table.	Example of performance tests carried out.	Japanese Government.	19	4
[/13	Table.	Example of running resistance and mechanical efficiency test carried out.	Japanese Government.	19	4
[/14	Table.	Example of train resistance test carried out.	Japanese Government.	19	4
J/1	Graph.	Relation between maximum drawbar pull and speed at different cut-offs, 4-4-0 three-cylinder locomotive on power test.	London and North Eastern.	20	4
J/2	Graph.	Relation between hourly water consumption and drawbar H.P., 4-4-0 three-cylinder engine.	London and North Eastern.	20	4

CHAPTER FIFTEEN.

Locomotive testing plants.

1 and 2. Location, date of erection and brief description.

Three Administrations only have installed complete locomotive testing plants.

The Pennsylvania plant, erected at the St. Louis Exposition in 1904, was transferred to Altoona in 1906. This plant is well illustrated in Appendices P/2 and P/3, and although only four pairs of supporting rollers with brakes are shewn, five pairs of coupled wheels can be dealt with at the present time.

The Great Western Railway plant was erected at Swindon Works in 1904, and is being extensively renovated this year. The plant is illustrated in Appendices P/4 and P/5, from which it will be seen that three of the five pairs of supporting rollers are braked. Belt drive from a pair of braked rollers to one pair of unbraked rollers enables an eight-coupled engine to be tested. An air compressor capable of absorbing 500 I. H. P. can be used as a brake when constant conditions are not required, and the speed does not exceed 50 m.p.h.

The Japanese Government Railways plant, originally constructed at Tokyo on the lines of the Pennsylvania plant, was destroyed by earthquake in 1923. It is at present under reconstruction,

and Appendices P/6 and P/7 give a general idea of the lay-out which is being adopted. Four pairs of supporting rollers form the test bed, the brakes being mounted so that either steam or electric locomotives can be tested. With electric locomotives a chain drive is used to couple four pairs of rollers together to test the individual axle drives.

An interesting plant, although not a complete testing plant (there being no brakes or dynamometer), was put down by the Baltimore and Ohio Railroad in 1924 with the object of testing boiler efficiency. The drive is by electric motor to a dummy axle, through which the valve gear can be operated. The engine piston is blocked in the mid-position and a dummy connecting rod and slide fitted. See Appendix P/1 for general arrangement diagram.

3. Type of brake and roller setting device to centre line of wheel.

The Pennsylvania and Japanese Government Railways employ the « Alden » absorption brake of the fluid friction type. In the former case three cast iron discs are used as the revolving elements, whilst in the Japanese design only two cast iron discs are fitted. The stationary elements in each case are copper diaphragms pressed against the disc faces by water pressure. Lubrication of the disc faces is by centrifugal action. See Appendices P/8 and P/11 for illustrations of these brakes.

The G. W. R. employ water-cooled band friction type brakes, power being applied through hydraulic rams. See Appendix P/10.

In all three cases the brakes are fitted at both ends of the supporting rollers.

On the Japanese plant the axle of the supporting rollers is carried on hydraulic cylinders in order to measure the hammer blow.

There is no uniformity of practice between any of the three Administrations in the method employed for ensuring that the vertical centre line of the wheels and rollers coincide. Two methods are employed by the Pennsylvania Railroad : I) a metal frame containing a spirit level is mounted on the top of the supporting roller so that co-incidence of centre lines is registered by the spirit level. A check by means of sliding scales from the ends of the metal frame to the tyre surface is also made; II) Appendix P/9 is a photographic illustration of the alternative method, and needs no description.

The G. W. R. method very closely resembles that of the system in use at Vitry, namely, the setting of the wheel and roller vertical centre lines to a common horizontal chord.

The Japanese Government Railways set direct by means of the plumb line, and Appendix P/12 illustrates this diagrammatically.

4. The dynamometer.

The Pennsylvania and Japanese Government Railways employ similar dynamometers of the lever type, resistance being taken by plate springs and torsion rod (see Appendix P/13). Neither Railway appears to be entirely satisfied with this type, the Japanese Government Railways reporting that a dynamometer of the hydraulic type is being contemplated owing to the inaccuracies caused by reciprocating balance at high speeds. The Pennsylvania Railroad increase the balance in the driving wheels so that the whole of the reciprocating weights are balanced for high-speed testing.

The degree of sensitivity of the Japanese Government Railways' dynamometer is given as eight degrees between pulls of 2.46 and 23.6 tons to give 1″ movement of the recording pen, resistance springs being changed to give this sensitivity.

The Pennsylvania Railroad in the determination of the accuracy give static

calibrations which shew the error not to exceed 2 % to 4 %. The readings are accordingly corrected.

The G. W. R. report that the design of the new dynamometer has not yet been finally settled.

5 and 7. **Capacity of the plant, and if gauge is variable.**

The following table sets out comparative particulars of the three plants :

Particulars.	*Pennsylvania Railroad.*	*G.W.R.*	*Japanese Government Railways.*
Maximum number of coupled axles braked	5	3	4
Minimum distance between vertical centre line of rollers . . .	4′ 2″	5′ 3″	5′ 2″
Maximum dimensions of locomotives which can be accommodated	38′ 4″ wheelbase.	...	32′ 2″ centre line of chimney to centre line of trailing axle.
Gauge, and whether fixed or variable	4′ 8 1/2″ fixed.	4′ 8 1/2″ fixed.	3.48 ft. fixed.
Maximum axle loading. coupled wheels.	Designed, 31.2 tons. Actual max. : 33.5 tons.	22.5 tons.	Normal, 16 tons. Actual maximum, 18 tons.
Maximum power absorbed in relation to brake speed. . . .	4 000 D.B.H.P. at 276 r.p.m. (8 brakes or 500 D.B.H.P./Brake).	2 000 *B.H.P.*	Drawbar pull of 14.75 tons.
Maximum speed of plant . . .	90 m.p.h.	80 m.p.h. actual (but this is not considered maximum).	Maximum not given, except as in excess of 62.5 m.p.h.
Maximum tractive effort of the dynamometer	80 000 lb. (35.7 tons).	Capacity of new dynamometer not yet decided.	79 500 lb. (35.4 tons).

6. **Use of test plant by other railways or by locomotive builders.**

With the exception of the Pennsylvania Railroad, the test plants are used exclusively by the owning Company.

In the case of the Pennsylvania Company, three other Railways have made use of the plant, and one locomotive builder on four separate occasions has tested engines. One manufacturer of locomotive equipment has also used the plant to test his products.

8. **Expansion and modification of plant.**

No modifications to their boiler efficiency plant are contemplated by the Baltimore and Ohio Railroad.

The Pennsylvania Railroad, from, experience, consider a general increase of size and dynamometer capacity desirable, coupled with improved facilities for handling coal, ash and cinder; the provision of roller bearings to the axles of the supporting rollers, and controls for speed (automatic) and boiler feed water temperature.

The Great Western Railway have, in the modernisation of the brakes of their plant, given more flexible control. The minimum distance between rollers cen-

tres of 5′ 3″ is an improvement just carried out.

The Japanese Government Railways, in addition to the consideration of a hydraulic dynamometer to replace the existing lever type, are contemplating the extension of the plant to accommodate the six driving axles of modern electric locomotives now in use on their system.

9. Special apparatus.

Only the Japanese Government Railways report the provision of special apparatus. A smoke density recording apparatus worked on the projected light and photo-electric cell principle is installed.

* * *

CHAPTER SIXTEEN.

Conducting tests on locomotive testing plants.

1 and 2. Preparation and time taken to instal locomotive on the plant.

The Pennsylvania Railroad, who alone give any detailed information under these headings, particularly stress the importance of coupled wheel diameters, allowing only 1/16″ difference in diameter between the wheels of any two axles. Wheels on the same axle must be exactly the same diameter on the tread. Journals must be concentric with tyres. Quartering must be checked and all reciprocating parts balanced. Frames and cylinders must be checked for alignment. Boiler tubes must be new, or newly pieced, and drawbar pin-hole bushed and reamered. Appendices Q/1, Q/2, Q/3 and Q/4 should be studied in connection with the location of the various measuring apparatus. Three to four days are usually required to instal the engine on the plant complete with the necessary apparatus, and the same length of time is quoted in the case of the Japanese Government Railways.

3. Method of conducting power and consumption tests.

The Pennsylvania Railroad test with full open regulator, maintaining uniform speed with a fixed cut-off.

The Great Western Railway run for about forty minutes to stabilise conditions prior to testing. Power tests are made under full regulator at varying cut-offs for the duration of half-an-hour each.

A full series of tests are run by the Japanese Government Railways, by making four or five tests at constant cut-off and varying speeds, and four or five more tests at constant speed with varying cut-offs. A total of 40 to 60 tests may be made, covering the entire range. All tests are made with full regulator.

4. Preparation of heat balance sheets.

Apart from the G. W. R., which prefers to make consumption tests in actual service with the dynamometer car, the preparation of heat balance sheets from plant tests follows accepted practice. The Pennsylvania and Japanese Government methods are reproduced as Appendices Q/5 to Q/14 inclusive.

CHAPTER SEVENTEEN.

Dynamometer cars.

1 and 2. Year built and date of subsequent major alterations (or additions), together with brief particulars of the cars.

Railways.	Year built.	Year altered	Brief detail of alteration.	Brief general description (excluding dynamometer).
uenos Ayres Great Southern	1927	...	...	Car carried on two four-wheeled bogies. Length 62′ 0″ over buffers. Amsler table with special apparatus for measuring drawbar-H.P. on three scales, inertia forces and total work done on drawbar on three scales. Travel of paper can be on distance or time basis with three rates of travel as regards time, and three stages for distance. « Maihak » indicator gear, with remote control.
ltimore and Ohio .	1913	1915	Paper mechanism drive, (new type).	Car carried on two four-wheeled bogies. Length 50′ 9″ over headstocks.
laware and Hudson	1905	1909	Dynamometer capacity increased.	No detailed information supplied.
nnsylvania . . .	1906	1920	Dynamometer capacity increased.	Car carried on two four-wheeled bogies, having 33′ 0″ centres. (Car fully described in Bulletin of International Railway Congress, January, 1906, page 264).
eat Western. . .	1900	...	...	Car carried on two four-wheeled bogies. Track wheel revolutions, 440 r.p.m. Special instruments comprise recording apparatus for moment of brake application on any vehicle.
ndon Midland and Scottish	1913	1929	New instruments added.	Car carried on two four-wheeled bogies. Spring-loaded track wheel located between wheels of leading bogie. Geared travel of paper over instrument table in six stages from 6″ to 20′ 0″ per mile. Rotating disc integrator and inertia ergometer fitted. Photographic plan of car underframe shewing table and push and pull springs in Appendix R/1.
ndon and North Eastern	1906	1933 & 1935	*1933* : Traction spring improved. *1935* : Transmission gear renewed and lay-out improved.	Car carried on two four-wheeled bogies. Length 50′ 6″ over buffers. Weight 32 tons 17 cwts. Rotating disc type integrator driven by spiral gear and universal joint from track wheel making 440 r.p.m. Electro-magnetic relay control on recording pens. Pyrometer, chronometer, speed indicators and counters are spring-supported, in addition to the instrument table, which is also vibration-damped. See Appendix R/2 for plan of lay-out.
uth African . .	1926	...	...	Car carried on two four-wheeled bogies ; the bogies and underframe constructed in America. The car is of specially rigid construction and drawbar pulls encountered with trains weighing 2 041 tons have been succesfully recorded.
eat Indian Peninula	1930/1931	. .	...	Car carried on two four-wheeled bogies. Special apparatus is installed to record work done by inertia forces. Track gear equipment. Anemometer and recording instruments for testing electric locomotives also included.
panese Government	1915	...	New car under construction.	New car under construction will be mounted on two six-wheeled bogies. A plan of the lay-out is shewn as Appendix R/3.

3, 4 and 5. **Particular**

Of the different types of dynamometer in use, the hydraulic type seems to be the most popular, six of the ten Administrations employing them.

	Buenos Ayres Great Southern.	*Baltimore and Ohio.*	*Delaware and Hudson.*	*Pennsylvania.*
Type.	Hydraulic.	Hydraulic.	Helical spring.	Hydraulic.
Capacity : Pulling forces (tons).	26.8	67	49	67
Buffing forces (tons).	26.8	Not designed to record these forces.	Amount not stated.	Amount not stated.
Sensitivity.	Three degrees. 1″ pull or buff for : 15 000 lb. 7 500 lb. 5 000 lb.	Pulls above 2 500 lb. accurate within 1 % of capacity of spring used.	No information supplied.	No information supplied.
Special features. . . .	Two cylinders are mounted between longitudinals of underframe. One piston used for pulling, the other for buffing. Maximum compression of spring 4″.	Pull transmitted directly to piston of 17.841″ diameter cylinder. Resultant pressure transmitted to recording cylinder. Piston movement restricted by interchangeable calibrated springs. Drawbar recording pen has maximum travel of 9″.	...	«Emery» piston ty with nest of helic springs under pre sure of 150 000 l (67 tons). Dra bar therefore rig within this loadin If load exceede force on hydraul piston is cushion by the sprin preventing strai Drawbar support on roller path.

CHAPTER EIGHTEEN.

Brake locomotives.

Only two Railways employ brake locomotives.

The Great Indian Peninsula Railway use electric freight locomotives capable of giving a resistance of 2 500 drawbar-H.P. at 18 to 25 m.p.h., but restricted to speeds below 35 m.p.h. With these locomotives the energy is dissipated by « regenerative » braking, assisted at low speeds by the application of the vacuum brake on both electric locomotive and dynamometer car.

The L. N. E. R. brake locomotive is a two-cylinder simple 4-6-0 passenger engine, an outline diagram of which is given as Appendix S/1. The lay-out of the steam and water pipes is also shewn on the diagram. The water pipe from the boiler is 3/4″ internal diameter, bifurcating at the smokebox, where connection is made to each cylinder, the diameter being restricted to 1/4″ on entering the cylinder. The steam pipe from the boiler is 1/2″ in-

the dynamometer.

The following table sets out the main characteristics of each dynamometer used :

Great Western.	*London, Midland and Scottish.*	*London and North Eastern.*	*South African.*	*Great Indian Peninsula.*	*Japanese Government (*).*
Laminated spring.	Laminated spring.	Laminated spring.	Hydraulic.	Hydraulic.	Hydraulic.
17	18	17.5	112	67	35.4
ot designed to record these forces.	14	Not designed to record these forces.	557	Amount not stated.	35.4
eflection 15/32″ per ton load.	No information supplied.	Deflection 0.45″ per ton load. No measurable difference between loading and unloading readings.	...	Three degrees. 1″ pull for : 12 500 lb. 18 750 lb. 37 500 lb.	0.15 % of maximum capacity.
oller separation of plates.	Buffing and draw springs are independent. Means for adjustment to suit load provided. Direct recording on paper roll, drawbar pull above and buffer thrust below datum line.	The dynamometer is supported on frictionless rollers.	This dynamometer was constructed in America.	...	...

ese particulars refer to the dynamometer of the car at present in use, and not of the new car under construction.

ternal diameter and leads into the blast pipe half-way down. Control valves for the water and steam are located in the cab of the brake locomotive.

Resistances of six tons at 25 m.p.h. in full gear, and 4 1/2 tons at 60 m.p.h. and 55 % cut-off have been obtained, but the best recorded performance over a distance of eight miles is the absorption of 1 520 drawbar-H.P. at 60 m.p.h. The maximum H.P. recorded is 1 850 but there was trouble with slipping. The Riggenbach system of braking has not been used on the L. N. E. R.

CHAPTER NINETEEN.

Conducting tests with dynamometer cars on trains.

1 and 2. **Preparation of the engine and time taken to fit up the necessary gear, etc., for testing.**

The extent of the preparation varies so considerably that no general conclusions can be drawn.

Time is also variable, an example of which is the difference in time taken to fit the necessary apparatus in the case

of the London Midland and Scottish (eight hours) and the Japanese Government Railways (two and a half days).

The Buenos Ayres Great Southern, prior to conducting efficiency tests with liquid fuel engines, fit the necessary steam piping from the cylinders to work the « Maihak » indicators, from which electric cables are taken to the recording apparatus in the dynamometer car.

The preparation on the L. N. E. consists of examining valves and pistons, blast pipes etc., checking safety valves and gauges, and the general examination of the engine for defects; occupying about two days.

Calibration of the boiler and tender on the South African Railways, and the checking of main dimensions such as wheel and cylinder diameters and examination of front end on the Great Indian Peninsula Railway, are the only items specifically mentioned, apart from the Baltimore and Ohio's adoption of the *Code for Preparation* drawn up by the American Society of Mechanical Engineers; the time of preparation being about four days in each case.

3. Method of conducting power and consumption tests.

These may be roughly divided into two categories of power and consumption testing : I) those carried out with the object of reproducing actual running conditions, and II) those which aim at establishing data under constant, or partly constant conditions, and in one or two instances maximum performance on the road.

In the first series the American Railways, the G. W. R. and the South African Railways may be grouped exclusively, and in the second category the Buenos Ayres Great Southern, the Great Indian Peninsula and the Japanese Government Railways. Power and consumption testing by both methods are common to the L. M. S. and L. N. E. Railways.

The method employed in carrying out tests under normal train working conditions is too well known to need detailed explanation and it is sufficient to mention, therefore, that continuous records of time, distance, speed and drawbar pull are taken, together with intermittent recordings of boiler and steam chest pressures, cut-off and regulator openings. From this data, and from particulars of the total coal and water consumed, the D.B.H.P., consumption of fuel and water per drawbar-H.P. or per mile, together with the evaporation, can be calculated.

In the case of dynamometer car trials under constant or partly constant conditions, power maxima for particular cut-offs are possible, and the Great Indian Peninsula Railway select a gradient of suitable length, adjust the cut-off until it is just possible to maintain steam and water, and run under these conditions for about two miles. The method put forward by the Japanese Government Railways is in effect similar, in that special trains are run in calm weather over continuous sections of upgrade. The L. M. S. and L. N. E. obtain their maximum performance data on favourable stretches of line under full regulator opening.

4. Exemples of tests.

Specimen results of tests carried out have been submitted by the Baltimore and Ohio and Japanese Government Railways in tabular form, Appendices T/1, T/2 and T/3, and T/12 to T/14, respectively; and in the form of graphs by the Buenos Ayres Great Southern, Appendix T/0; the G. W. R., Appendices T/4 and T/5; the L. N. E. R., Appendix T/8; and the Great Indian Peninsula, Appendices T/9 to T/11. These test results have been compiled on generally

accepted lines and cover a wide field of testing.

The L. N. E. R. has included, in Appendix T/7 I), a list of some of the different kinds of tests carried out, together with particulars (Appendix T/6 I) of the headings under which information is compiled. The L. M. S. R. has set out, in Appendix T/7, the various types of test conducted and in Appendix T/6, the headings under which particulars are obtained, and although no specific results have been included by this Administration, test results of new engines have been given in Appendix L/34 (Part Two, Chapter 12 of this report).

Similarly, test results of their new *Pacific* locomotive (see Report, Chapter 12, Question 2) give an example of the South African Railways' tests carried out. This Administration has also investigated questions of chimney, blast pipe, spark arrestor and fire grate design by means of the dynamometer car.

The Japanese Government Railways, in addition to the test data supplied, conduct performance tests of electric and diesel locomotives, comparative tests of locomotives before and after alteration, and examination of operative abilities of the engine crew.

* * *

CHAPTER TWENTY.

Conducting tests with dynamometer cars and brake locomotives.

Only the London and North Eastern Railway has reported on the questions asked under this Chapter.

The preparation of the engine and the time taken to fit up the necessary gear is practically the same as in the case of testing with dynamometer car only. The test train is formed with the engine under trial leading, the dynamometer car in the middle and the brake locomotive last.

The method of testing for power, after selection of the particular speeds and cut-offs at which information is required, is to set the engine under test in the required cut-off and open the regulator slightly. The brake locomotive assists up to within 5 m.p.h. of the prearranged speed, after which the regulator of the engine under test is fully opened. The brake locomotive is then put slowly into reverse gear, the regulator still remaining open. The water injection valves to the cylinders. and steam valve to the blast pipe are opened, and by means of the reversing gear on the brake locomotive, the speed is maintained at the required figure. Similar tests are made for varying cut-offs and speeds over the whole range.

Consumption tests have so far been confined to water consumption. Two speeds and two cut-offs are selected and the brake locomotive is used in the same manner as for power testing, comparison being made between water consumption and work done.

Prior to making either power or consumption tests, a distance of about 10 miles is run to warm up.

Appendices U/1 and U/2 give examples of power and consumption tests made.

* * *

CHAPTER TWENTY ONE.

A. Nature of tests.

a) **Tests carried out on the test plant only.**

The Pennsylvania Railroad confine power and consumption testing of locomotives to the stationary plant. 75 locomotives, both steam and electric, have been fully tested between 1906 and 1932.

The Great Western Railway carry out steam consumption tests on their plant and tests to determine modifications necessary to valve gear.

The Japanese Government Railways do not confine any particular tests to the plant alone. Testing generally, free from the influence of weather, track conditions, voltage changes, etc., is undertaken. Exact comparisons of different locomotives and determination of the actual values of fuels are tests also carried out.

The opinion expressed by the Great Indian Peninsula Railway is that more accurate results could be obtained from the test plant for information on the temperature of bearings at various speeds, balancing and effect on the drawbar, and draught and smokebox conditions.

b) **Tests carried out on the line.**

I) *With dynamometer car only.*

A variety of tests are carried out by this means.

The American Railways utilise the dynamometer car for the correct determination of tonnage rating of trains; the Baltimore and Ohio, in addition, conduct power and consumption tests, tests of air brake operation, train resistance and examination of problems connected with the speeding up of schedules, whilst the Delaware and Hudson Company limit the tests carried out to consumption, and acceleration and retardation tests, in addition to the tonnage rating tests.

The Great Western Railway conduct full heat balance trials with the dynamometer car, and the L. M. S., L. N. E., and South African Railways carry out tests on general locomotive performance under working conditions, together with certain testing of special features (fuels etc., in the case of the L. M. S.). The L. N. E. R., in certain cases over favourable section of line, obtain information on the maximum output of the engine, which serves as a useful guide in the timing of trains. Brake tests, and tests of train resistance are also made.

The Great Indian Peninsula Railway find the dynamometer car, together with the brake locomotive in some cases, indispensable to the determination of capacity under service conditions. Resistance of the engine and train, and of the track are determined, and oscillation tests also made.

The Japanese Government Railways carry out tests on the general performance of locomotives under the influence of weather and track conditions. Engine and train resistance are determined and comparative tests with other locomotives made.

II) *With dynamometer car and brake locomotive.*

The use of brake locomotives being confined to the London and North Eastern and Great Indian Peninsula Railways, the range of tests carried out is necessarily limited. Both Railways carry out power and consumption tests, but the L. N. E. R. concentrate rather on maximum output of power at varying cut-offs and speeds, whereas the G.I.P. utilise the brake locomotive as a definite and fixed resistance and perform their tests to discover capacity under working conditions. The determination of the relationship between pressure and temperature at various points in the steam circuit at different power outputs is one form of testing applied by the L. N. E. Railway.

c) **Tests carried on the test plants and or on the line.**

The Pennsylvania and Great Western Railways do not carry out similar types of test by the two methods, but the Japanese Government Railways do carry out performance tests by both methods.

The Great Indian Peninsula Railway suggest that indicator diagrams could be taken equally as well on the test plant as on the line.

B. Comparison of results.

1. Results obtained with similar tests carried out on the plant and on the line.

Since only the Japanese Government Railways attempt to carry out similar tests by the two methods, it is to be regretted that no data of actual tests is available. However, the opinion formed by this Administration is that corrections should be made for such differences as exist in drawbar pull and heat balance. In the case of plant tests, the drawbar pull recorded would be of a higher value owing to the absence of the tender and of friction, wind and track resistances. Similarly, allowance should be made for the greater loss due to radiation in the determination of heat balance by service tests.

2. Time occupied in carrying out similar tests on the plant and on the line, and on the line only, by dynamometer car and brake locomotive, and by dynamometer car only.

Plant and line tests :

The Japanese Government Railways report that performance testing on the plant occupies about two days (this is additional to the time taken to set the engine on the plant and couple up). No specific time is given by this Railway for similar line tests.

Line tests only :

The London and North Eastern Railway reports that there is little difference in the time occupied in carrying out similar tests with or without brake locomotive, but the South African Railways state that no comparison is available, about fourteen days being occupied to conduct performance tests including indicating with dynamometer car only. The electric (freight) brake locomotives are used only to test goods engines.

C. Conclusion on the merits of the three methods of testing.

1. Conclusions on plant and line testing.

(See also brief summary of individual replies).

The views expressed by the six Administrations replying to this question are set out in full in the Summary. The only two Administrations to agree practically unanimously are the Pennsylvania Railroad and the London and North Eastern Railway, and the main points in agreement are : I) that it is extremely difficult to obtain accurate comparisons from line tests under working conditions with dynamometer cars only; II) that accuracy would be greatly increased by the addition of brake locomotives, and III) that test plant results are strictly accurate and comparable one with another. The last view expressed is also shared by the Great Western Railway, when applied to cylinder conditions, but full heat balance tests are conducted on the line by this Railway, because boiler steaming is adversely affected when running on the plant.

The Japanese Government Railways express an independence of opinion which is interesting in view of their plant and line testing experience. They claim that each has its special merits and that both are used, but the method of testing depends entirely on the form in which the results are required.

The L. M. S. express the view that line tests with dynamometer cars afford a sufficiently accurate guide to capacity for everyday working conditions; dynamometer cars and brake locomotives provide matter for theoretical comparison only, whilst stationary plants still further cut out the varying conditions met with on the line and serve only as a theoretical guide to engine performance under ideal conditions. It is agreed that the test plant is the ideal means for obtaining actual engine performance, throughout the full range of working conditions.

The Great Indian Peninsula Railway express the view that given a level section of line about 80 miles in length, constant conditions can be very closely approximated. Taking into consideration the cost of testing, this Railway would prefer dynamometer car testing with specific test load to the stationary plant, but point out that the duration of stationary tests is valuable from the point of view of accuracy. It is stated that the most complete information would only be obtainable by testing with a combination of the stationary plant, and line tests with the dynamometer car.

2. **Evaluations of savings claimed for various devices by means of plant and line tests.**

The Pennsylvania Railroad report that the testing of comparative efficiency of special devices is, wherever possible, carried out on the test plant.

The Great Western Railway state that it has been impossible to make any comparisons.

The London and North Eastern Railway have no direct experience of testing special fittings by means of a test plant, but express the opinion that accurate comparisons could be made by this means, and consider the test plant to be ideally suited to this purpose.

The Japanese Government Railways utilise the plant for the testing of devices associated with the locomotive when under power but point out that special fittings used in coasting can only be tested on the line.

Summary of individual replies (Chapter 21).

C. Comparison between testing locomotives on a stationary plant and on the line.

1. **What conclusions have been formed on the relative merits of carrying out tests on a test plant and on the line? For example, the claim is made that for comparative purposes the results obtained on a test plant are superior inasmuch as the conditions under which the tests are made are identical. On the other hand, conditions on the test plant are not comparable with those obtaining in normal service on the line or with brake-locomotive tests.**

Discuss this briefly and say which is preferred.

Pennsylvania RR. — It is considered accurate results cannot be obtained with trains of varying resistance and speed on the line and for this reason a true measure of locomotive efficiency is impossible. Accuracy would be greatly increased by the use of a brake-locomotive, assuming constant speeds and loads. The accuracy of such a test could not be comparable, however, with that of a test made on a stationary plant. The only disadvantage of the stationary test seems to be that it does not measure the air resistance and the resistance of the leading and tender trucks.

Great Western Railway. — For certain tests on cylinder conditions, the stationary test plant is superior on account of the stable conditions, but full tests for heat balance figures are only carried out on the line because boiler steaming is adversely affected when running on the plant.

London, Midland and Scottish Railway. — Dynamometer car tests under working conditions considered a satisfactory method of obtaining engine performance with regard to everyday working capacity. They afford a sufficiently accurate guide for the operating department in respect to capacity. Dynamometer car tests with brake-locomotives (constant speeds and cut-offs) provide matter for theoretical comparison and are of little use as a guide to general locomotive performance. Stationary plant tests still further cut out the effect of varying conditions met with on the line, and can only be used as a theoretical guide to engine perfor-

mance under ideal conditions. It is agreed that for obtaining the actual engine performance under all varying conditions of operating, the stationary test plant may be considered the ideal means.

London and North Eastern Railway. — This Company has not had any direct experience with test plant work except for the test carried out with the P. 2 type engine, No. 2001, « Cock of the North » at Vitry, in 1934-35. Stationary plant testing provides a strictly uniform basis for comparative trials, and is the best method for determining the effects of changes in design. Testing on the line by means of a dynamometer car, whilst reproducing the actual working conditions at the time of testing, does not ensure a uniform basis for comparative purposes. Testing by means of brake-locomotives in conjunction with a dynamometer car is the most accurate method of testing engines on the line; conditions of load and speed may be controlled more exactly and the tests repeated as often as required. Stationary plant results do not reproduce working conditions and such trials should be implemented by tests on the line to determine the capacity, efficiency and behaviour of the locomotive under these conditions.

Great Indian Peninsula Railway. — If a level section of road, about 80 miles long is available, constant conditions can be approximated. If the proportionate expenses of testing are considered, the use of a dynamometer car with specific test load would be preferred to testing on the stationary plant or by means of a dynamometer car in ordinary service. From the point of view of accuracy, the long duration of stationary plant tests is valuable. The combination of the stationary test plant and the dynamometer car for roads tests would give the most complete results.

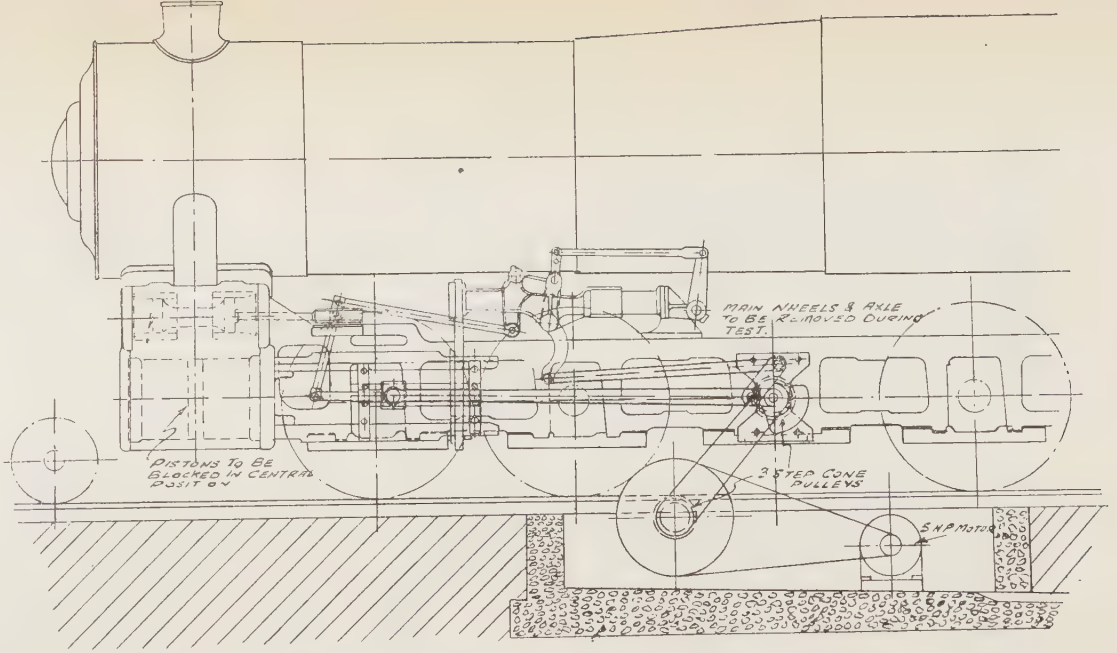
Japanese Government Railway. — Depending entirely on the nature of test to be made and in what form the results are required, the method of testing (i.e. by stationary plant or line tests), is selected. Each form has its special merits and both are used.

(See Summary on page 1444/154.)

APPENDIX P/1.

Boiler efficiency testing plant.

Baltimore and Ohio Railroad.



APPENDIX P/2. — **Longitudinal section of Altoona test plant.** — Pennsylvania Railroad.

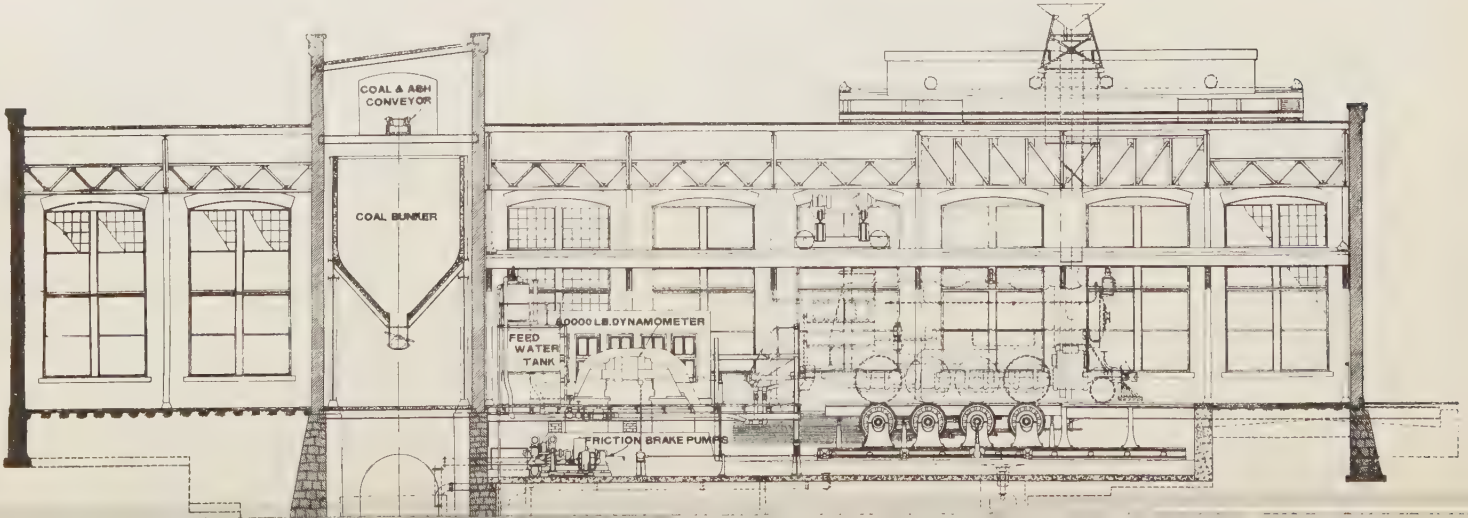


TABLE 2.

Total weight (metric tons) in running order of the heaviest vehicles and diagrams of weight distribution.

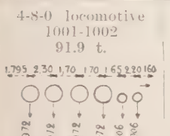
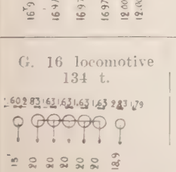
ADMINISTRATIONS.	Steam locomotives.	Electric locomotives.	High-capacity goods wagons.	Railcars.	Passenger carriages and other vehicles.	Miscellaneous. Breakdown cranes, etc.
Eastern State	102 t.	...	2-bogie rail wagons (empty 22 t.; capacity 40 t.)	21.5 t.	AB4 carriage (48 t. tare) 54 t.	...
Southern State	Tender locom. 94.65 t.	...	Tank wagon 52 t.	*Sentinel* motor train with 2 coupled units 66.05 t.	Steel carriage 48 t.	...
Railways of Spain (5' 6" gauge) .	113.1 t.	152 t.	65 t.	54.75 t.	53 t.	...
	The weight distribution to be such that the weight per lineal metre does not exceed 6 t. and the distance between two axles carrying 17 t. exceeds or equals 2 metres.					
Nord-Luxembourg and Alsace (5' 6" gauge) .	Locomotive of the standard train of the Instruction. 100 t.	...	Wagon of the standard train of the Instruction.	51.8 t.	C.W.FFy. carriage 47.4 t.	...
Railways of Spain (5' 6" gauge) .	4-8-0 locomotive 1001-1002 91.9 t. 	...	8-wheeled wagon : 60 t. 4-wheeled wagon : 34 t.	...	8-wheeled carriage : 52 t.	
Eastern Lorraine	G. 16 locomotive 134 t. 	...	80 t. 4 pairs of wheels carrying 20 t. 2 bogies.	...	52 t. 4 pairs of wheels carrying 13 t. 2 bogies.	

TABLE 2. *(Continued.)*

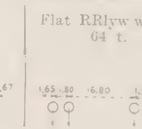
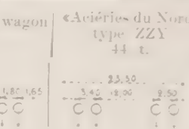
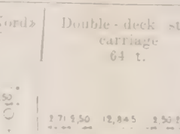
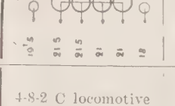
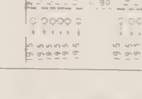
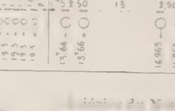
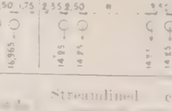
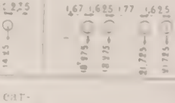
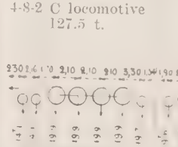
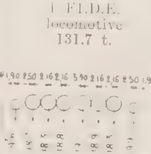
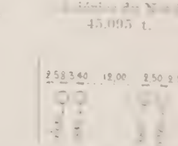
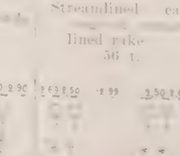
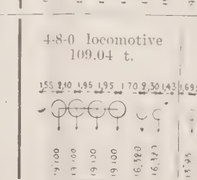
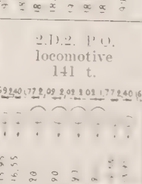
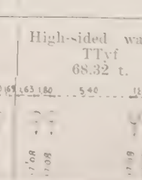
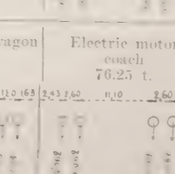
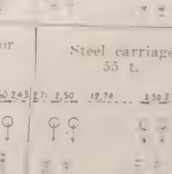
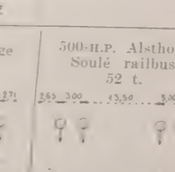
ADMINISTRATIONS.	Steam locomotives.	Electric locomotives.	High-capacity goods wagons.	Railcars.	Passenger carriages and other vehicles.	Miscellaneous. Breakdown cranes, etc.
French Est.	Rule based on the maximum load per lineal metre of the vehicle uniformly distributed over the whole length over buffers : this maximum load is : 8 t.	...	7.2 t. on some lines 5.4 t. everywhere	7.2 t. 5.4 t.	7.2 t. 5.4 t.	...
French State	*Mountain* locomotive 126.36 t.	Locotractor 62.64 t.	Flat RRlyw wagon 64 t. 	«Aciéries du Nord» type ZZY 44 t. 	Double-deck steel carriage 64 t. 	
French Nord	2-8-2 Suburban tank locomotive 122.5 t. 	...	Special 150-ton transformer wagon. 235 t. 	Sentinel steam 61.25 t. 	All-metal 3rd-class express carriage 57 t. 	Breakdown crane of 32 t. 80 t. 
Paris-Lyon-Méditerranée . . .	4-8-2 C locomotive 127.5 t. 	1 FI.D.E. locomotive 131.7 t. 	...	45.095 t. 	Streamlined carlined rake 56 t. 	...
P.O.-Midi (France).	4-8-0 locomotive 109.04 t. 	2.D.2. P.O. locomotive 141 t. 	High-sided wagon TTyf 68.32 t. 	Electric motor coach 76.25 t. 	Steel carriage 55 t. 	500-H.P. Alsthom-Soulé railbus. 52 t. 

TABLE 2. *(Continued.)*

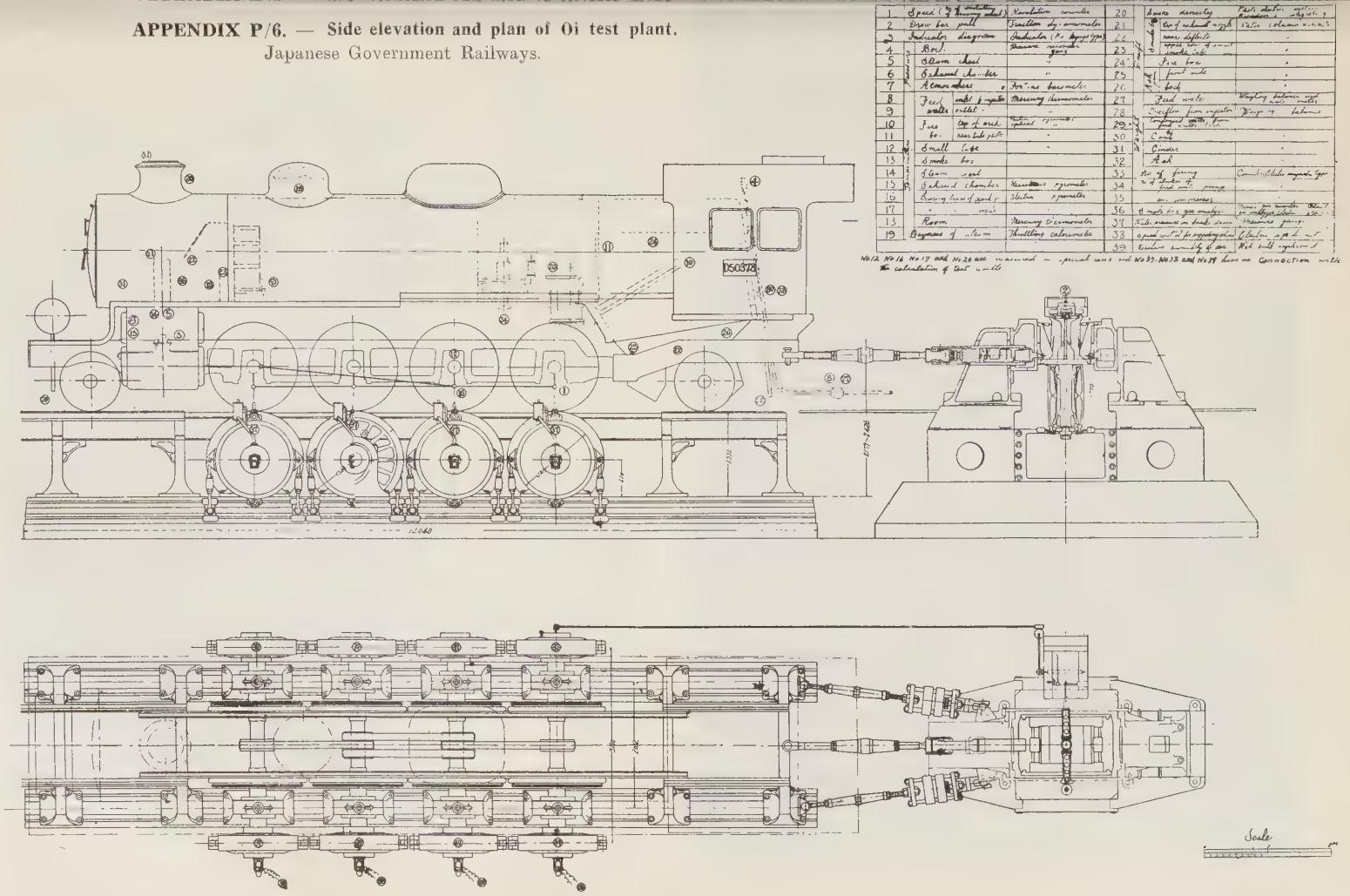
ADMINISTRATIONS.	Steam locomotives.	Electric locomotives.	High-capacity goods wagons.	Railcars.	Passenger carriages and other vehicles.	Miscellaneous. Breakdown cranes, etc.
French Systems . . . . . Standard train as defined by Ministerial Note of the 10th May 1927.	Locomotive 100 t.	Tender 60 t.	Locomotive 100 t.	Tender 60 t.	Wagon 80 t.	Wagon 80 t.
Algerian Rys.	...	...	64 t.	...	...	...
Tunisian Rys. — Standard gauge .	4-6-2 locomotive 76.8 t.	...	Mineral wagon 48 t.	265-H.P. Renault railbus 39.5 t.	A^3B^4 carriage 39.25 t.	...
Tunisian Rys. — Metre gauge. . .	*Mallet* locomotive 76.9 t.	...	Mineral wagon 45.43 t.	...	Restaurant car 30.55 t.	...
Colonial Railways in French West Africa . . . . . (Metre gauge).	*Mallet* locomotive 59.55 t.	...	20 t. load 35.8 t.	...	3rd-class carriage 23.6 t.	25 t. travelling crane 42 t.

TABLE 2. *(Continued.)*

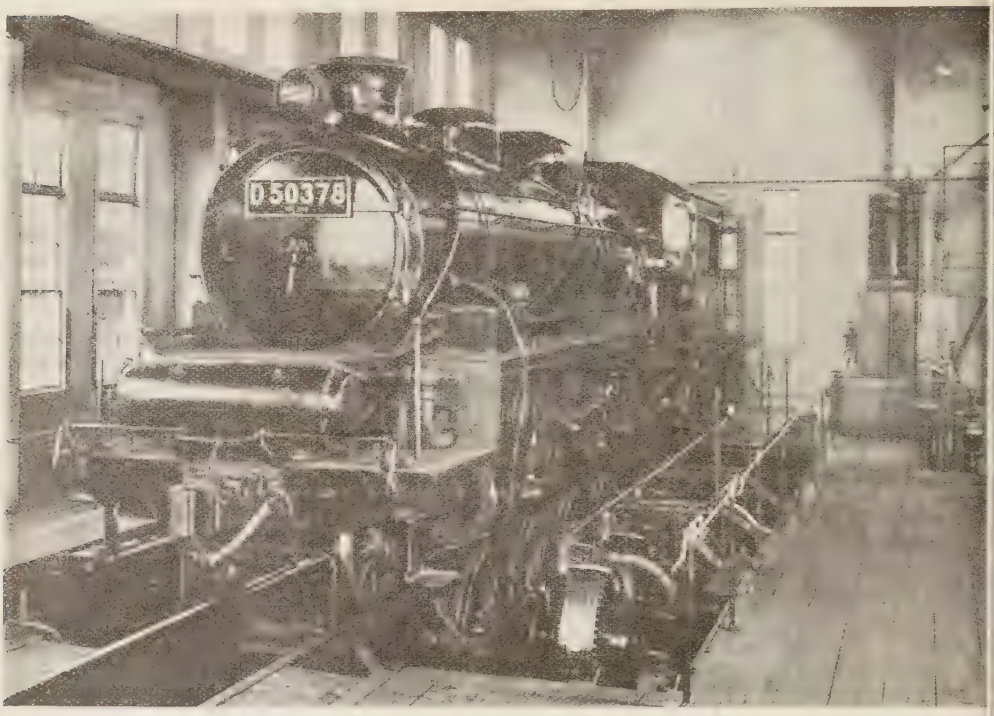
ADMINISTRATIONS.	[illegible] locomotives.	[illegible] locomotives.	[illegible] goods wagons.	Railcars.	[illegible] and other vehicles.	[illegible] Breakdown cranes, etc.
Portuguese Rys.	2-8-4 tank locomotive 103.68 t.	...	...	...	Tare 52 t. Load 5 t. 57 t.	
Mozambique Rys.	84 t.	...	62 t. 4 pairs of wheels of 15.5 t.	19.2 t. 3 pairs of wheels of 6.4 t.	38 t. 4 pairs of wheels of 9.5 t.	...
Rumanian State.	Locomotive 601 163 t.	...	63 t.	...	Restaurant car 59.448 t.	...
Czechoslovak State.	4-8-2 locomotive 103.7 t.	AAAA locomotive 67.6 t.	60 t.	56 t.	52 t.	
Turkish State.	91.29 t.	...	...	16 t. 2 pairs of wheels carrying 8 t.	50 t. 4 pairs of wheels carrying 12.5 t.	...
Jugoslav State	2-10-0 locomotive 106.155 t.	...	Wagon for carrying locomotives 78 t.	66 t.	Special carriage 67 t.	...

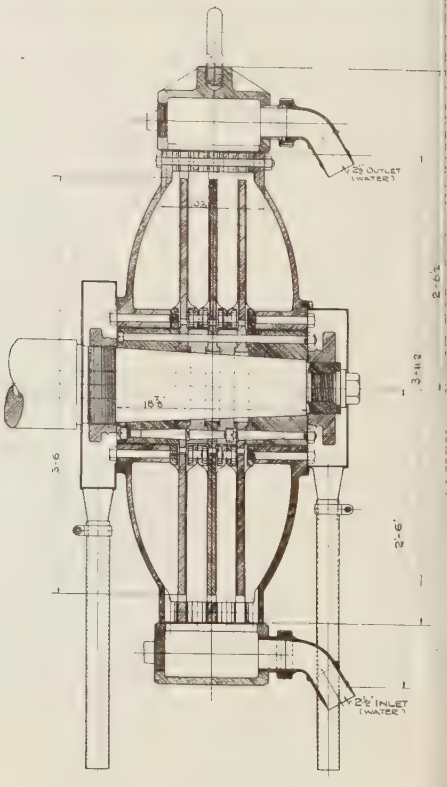
APPENDIX P/6. — Side elevation and plan of Oi test plant.

Japanese Government Railways.



APPENDIX P/7. — Arrangement of Oi test plant with engine in position.
Japanese Government Railways.

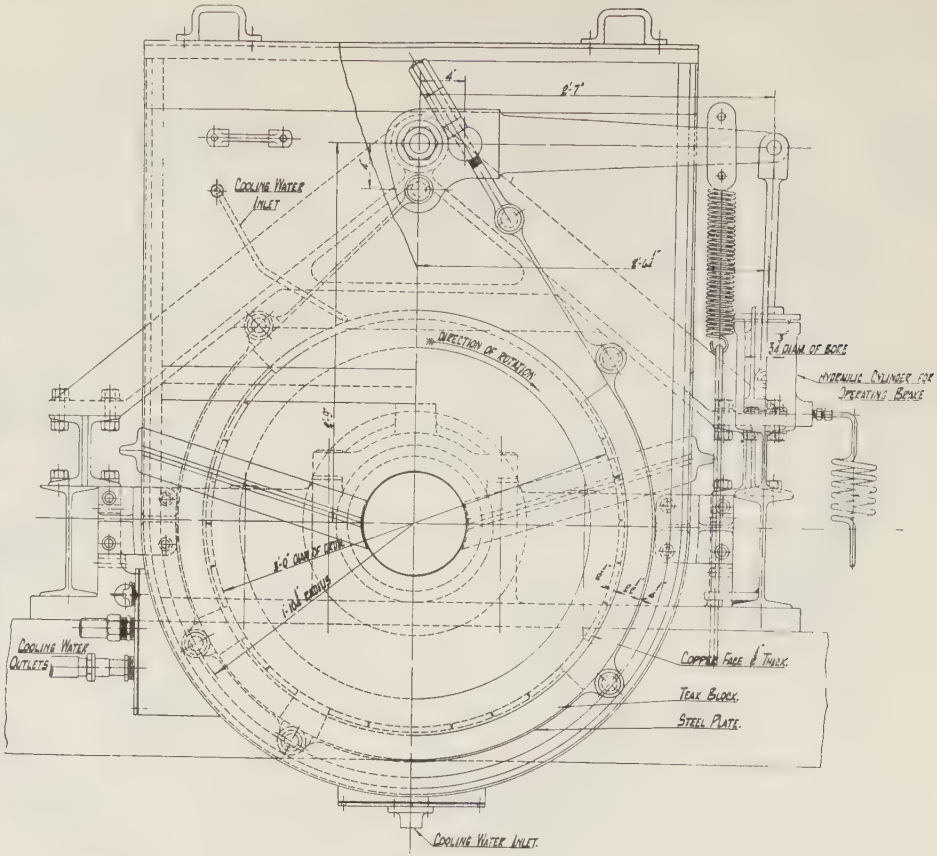




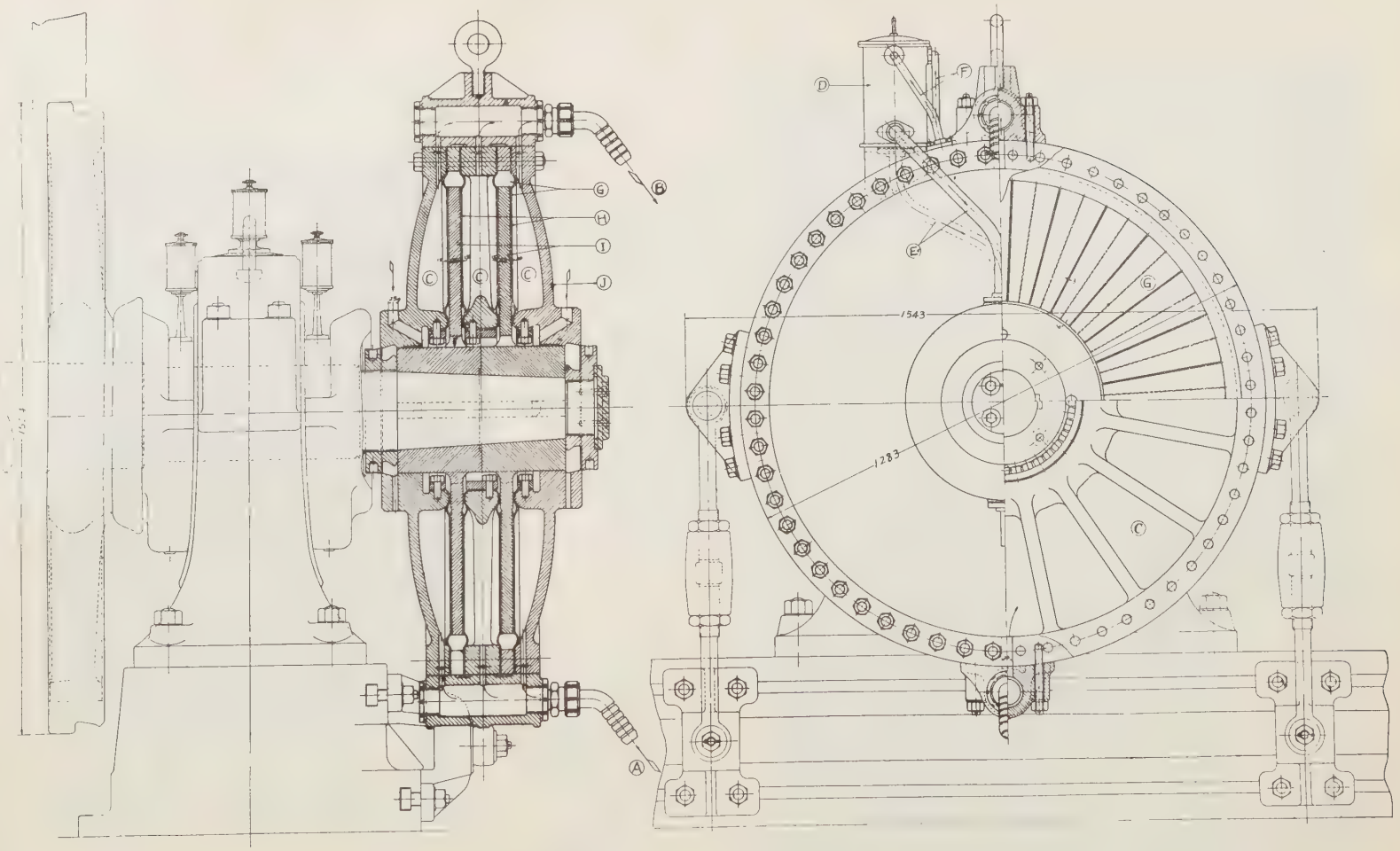
APPENDIX P/8. — Arrangement of « Alden » friction brake (three revolving elements).
Pennsylvania Railroad.

APPENDIX P/9. — **Alternative method of setting engine wheel on brake roller.** — Pennsylvania Railroad.

APPENDIX P/10. — **Arrangement of water-cooled friction brake.** — Great Western Railway.



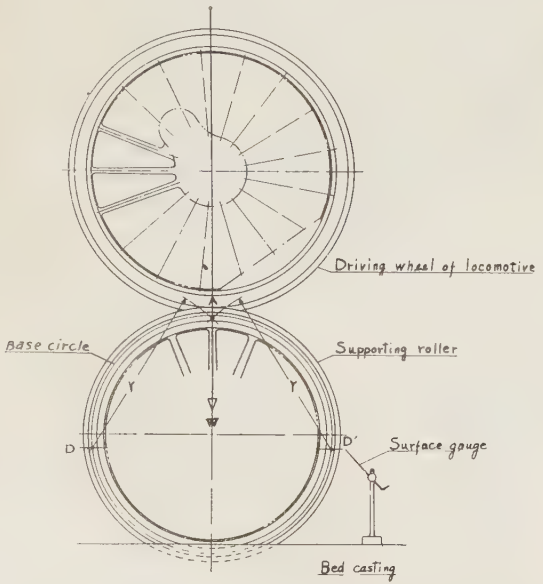
APPENDIX P/11.— Arrangement of « Alden » friction brake (two revolving elements). — Japanese Government Railways.



Note:

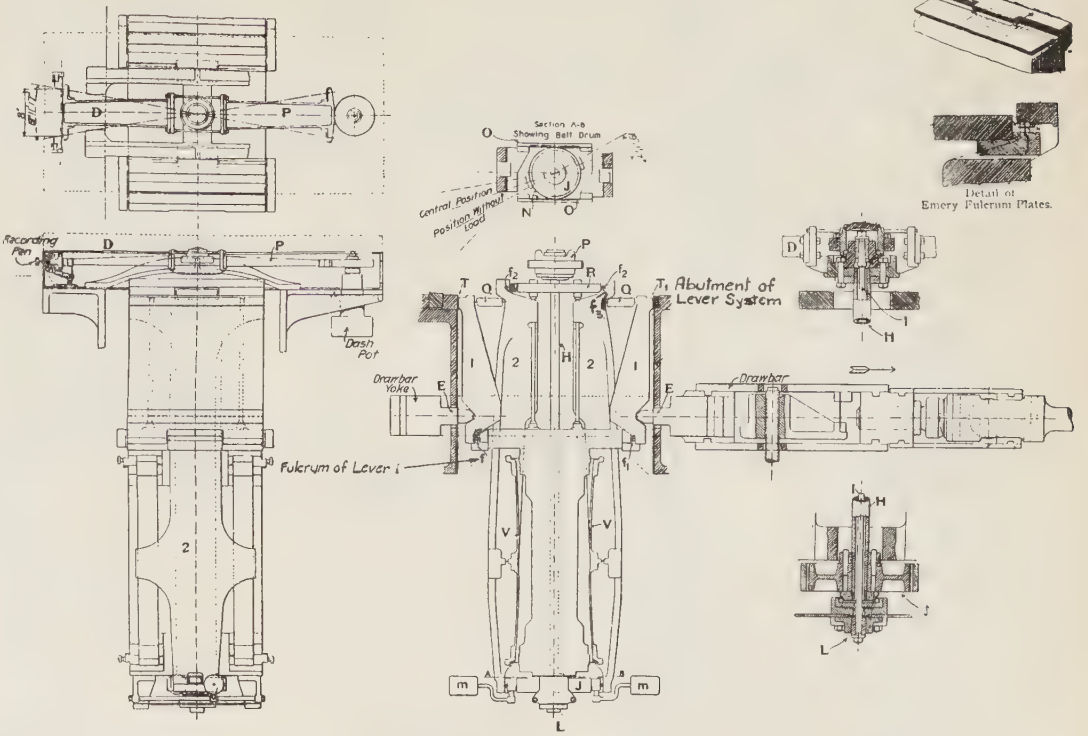
A Water inlet (pressure water from turbine pump).
B Water outlet (discharge water).
C Water under pressure.
D Oil pot.
F Lubricating oil pipe (outlet).
G Lubricating oil.
H Copper diaphragm.
I Disc plate.

APPENDIX P/12. — Method of setting engine wheel on brake roller. — Japanese Government Railways.



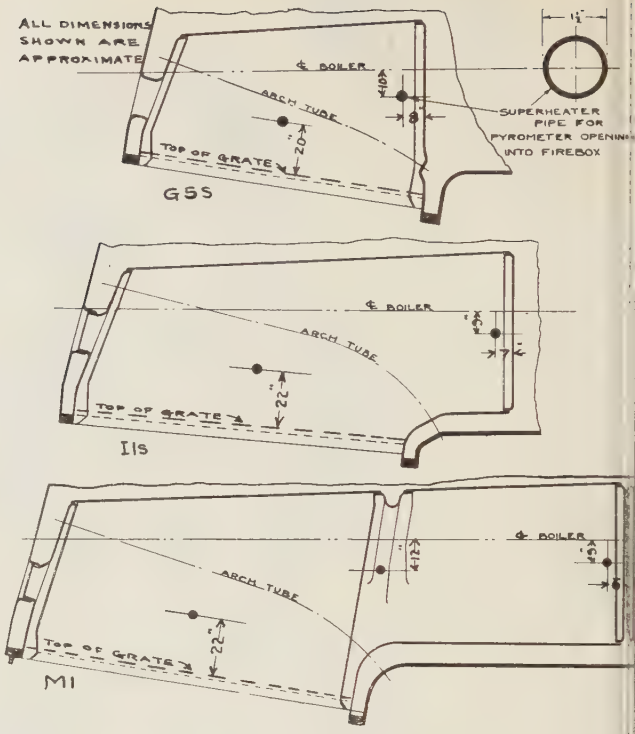
Note: The base circle, the centre of which will coincides with the centre of the tread circle, is marked on the side surface of the tyre.

APPENDIX P/13. — Weighing type lever dynamometer. — Pennsylvania Railroad.

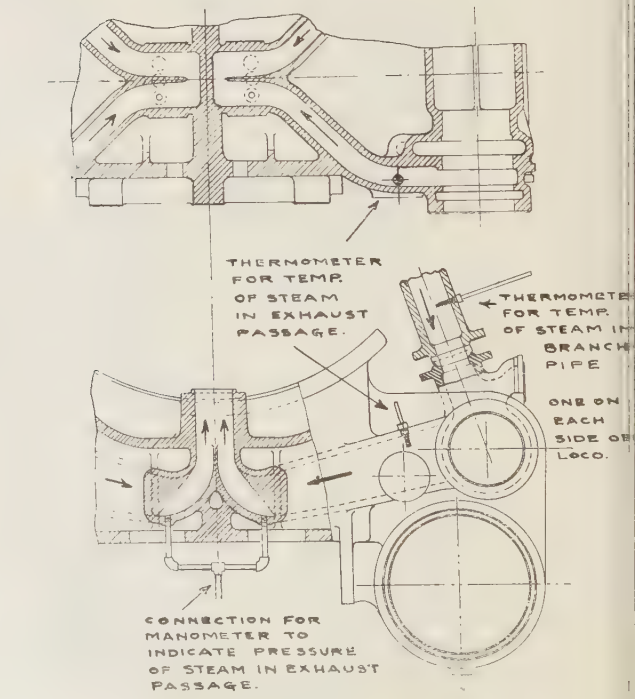


Drawbar pull is applied at E in direction of arrow, and using F as fulcrum, left-hand lever (1) acts through top of lever system with T.1 as the abutment. Using f.2 and f.3 as fulcrums for the right- and left-hand large levers (2), lower ends of these two levers both move inwards against the resistance of the springs vv. Inward movement of these levers also turns drum J and tube H. Tube H contains a torsion rod securely fastened to the structure at the bottom, and free to move with tube at top. The torsion of this rod provides the final resistance of the dynamometer.

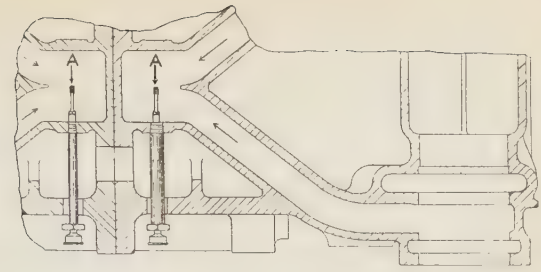
Tube H is also connected to indicating pencil by means of the arms P. Maximum forward pull of drawbar under full load and, therefore, of the engine on the rollers is 0.04" a figure which is multiplied 200 times on the chart at the dynamometer table.



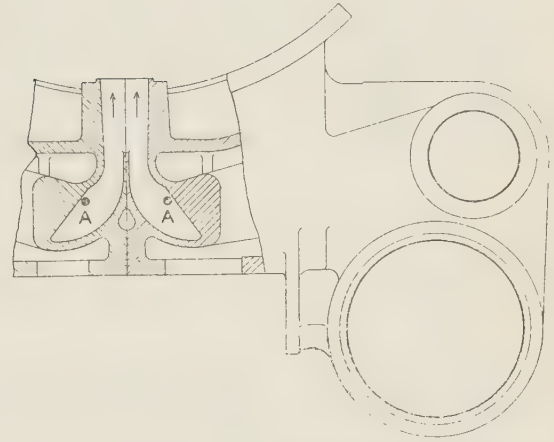
APPENDIX Q/1.— Location of pyrometers in firebox. — Pennsylvania Railroad.


THERMOMETER FOR TEMP. OF STEAM IN EXHAUST PASSAGE.
THERMOMETER FOR TEMP. OF STEAM IN BRANCH PIPE
ONE ON EACH SIDE OF LOCO.
CONNECTION FOR MANOMETER TO INDICATE PRESSURE OF STEAM IN EXHAUST PASSAGE.

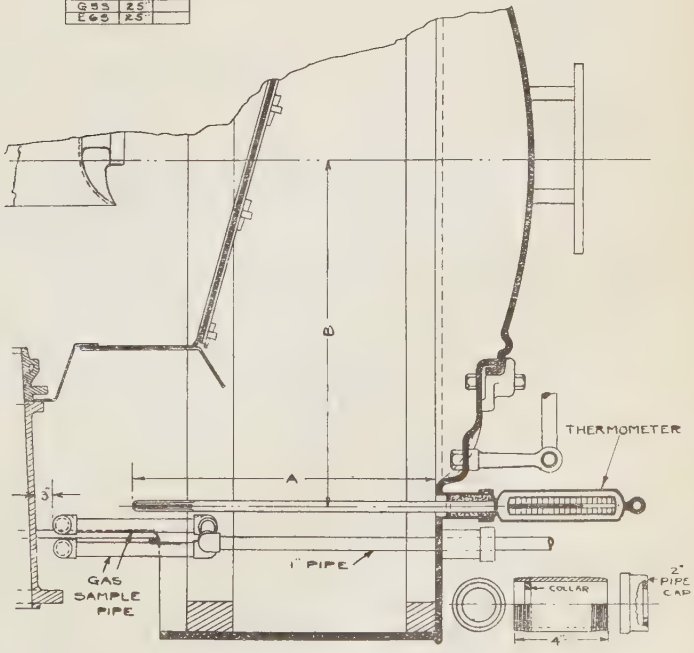
APPENDIX Q/2. – Location of connections for measuring temperature in steam and exhaust passages and back pressure. — Pennsylvania Railroad.



PENDIX Q/3. — Location of thermo-couples or measuring temperature of exhaust steam.
Pennsylvania Railroad.



LOCO. CLASS	A	B
I 1 S	25"	32"
M 1 S	25"	32"
L 1 S	25"	27"
K 4 S	25"	27"
Q 2 S	25"	
E 6 S	25"	



PENDIX Q/4. — Location of thermometer and gas sampling tubes in smokebox.
Pennsylvania Railroad.

APPENDICES Q/5 to Q/10. — Forms used in the calculation of the heat balance for the boiler, with typical results. — Pennsylvania Railroad.

APPENDIX Q/5.

LOCOMOTIVE:
TYPE . . . .
CLASS . . . .
NUMBER . . .

THE PENNSYLVANIA RAILROAD.
TEST DEPARTMENT.

COMBUSTION CALCULATIONS — FRY METHOD.

Report No. .....
Altoona, Pa., *3-10-32.*

Test No.	Dry coal fired per hour.	Equivalent evap. per hour.	Efficiency of boiler.	Heat loss due to radiation. 0.05 × item 41	CO + CO_2 29 + 29*b*	Sensible heat per pound of gas (*). At smoke-box temp. 25	Sensible heat per pound of gas (*). At labor temp. 24*b*	Sensible heat per pound of gas (*). Net above labor temp. (B-C)	Weight dry gas per pound of coal burned. 2.52 × 28*J* / A
	Pounds.	Pounds.	Percent.	Percent.	Percent.	Btu.	Btu.	Btu.	Pounds.
1	33*c*	37*b*	41	41*a*	A	B	C	D	E
521-A	*7617*	*60926*	*55.4*	*2.8*	*12.8*	*568*	*82*	*486*	*15.407*

(*) Sensible heat = t (0.235 + 0.000014 t.) where t = gas temperature, deg. F.
See also « A study of the loco. boiler » Fry, page 117.

APPENDIX Q/6.

LOCOMOTIVE:
TYPE . . .
CLASS . . . .
NUMBER . . .

THE PENNSYLVANIA RAILROAD.
TEST DEPARTMENT.

COMBUSTION CALCULATIONS — FRY METHOD.

Report No. .....
Altoona, Pa., *3-10-32.*

Test No.	Designation.	Temperature Deg. F. Air in laboratory.	Temperature Deg. F. Gas in smoke-box.	Calorific value per pound. Dry coal.	Calorific value per pound. Combustible.	Ash in dry coal.	Carbon in coal.	Hydrogen in coal.	Smoke-box gas. Carbon di-oxide (CO_2)	Smoke-box gas. Carbon mon-oxide (CO)
		Deg.	Deg.	Btu.	Btu.	Percent.	Percent.	Percent.	Percent.	Percent.
1	1*a*	24*b*	25	28*a*	28*b*	28*h*	28*j*	28*k*	29	29*b*
521—A	*200—40 F*	*82*	*568*	*13903*	*15279*	*8.16*	*78.26*	*5.05*	*12.6*	*0.2*

APPENDIX Q/7.

LOCOMOTIVE:
TYPE . . . .
CLASS . . . .
NUMBER . . .

THE PENNSYLVANIA RAILROAD.
TEST DEPARTMENT.

COMBUSTION CALCULATIONS — FRY METHOD.

Report No. .....
Altoona, Pa., *3-10-32.*

Test No.	Weight mixed gas per lb. coal burned. $E + \frac{9\ (28h)}{100}$	Total sensible heat per lb. coal burned. (F × D).	Total sensible and latent heat in smoke-box gas per lb. coal burned. $\frac{9\ (28h)\ 970}{100} + G$	CO loss in smoke-box gas per lb. of coal burned. $\frac{296}{10160} \times \frac{28J}{100} \times A$	Total loss in smoke-box gas per lb. of coal burned. H + I	Total sensible and latent heat in smoke-box gas in percent of heat in coal burned. $100 \times \frac{H}{28a}$
	Pounds.	Btu.	Btu.	Btu.	Btu.	Percent.
1	F	G	H	I	J	K
521-A	*15.861*	*7708.45*	*8149.3*	*124.24*	*8273.54*	*58.61*

APPENDIX Q/8.

LOCOMOTIVE:
TYPE . . . .
CLASS . . . .
NUMBER . . .

THE PENNSYLVANIA RAILROAD.
TEST DEPARTMENT.

COMBUSTION CALCULATIONS — FRY METHOD.

Report No. .....
Altoona, Pa., *3-10-32.*

Test No.	CO loss in percent of heat in coal burned. $\frac{1}{28a} \times 100$	All losses in smoke-box gas in percent of heat in coal burned. $\frac{J}{28a} \times 100$	Heat taken up by boiler in percent of heat in coal fired. Item 41 + Item 41*a*	Heat taken up by boiler in percent of heat in coal burned. 100-M	Air supplied per pound of coal burned. $\frac{28h}{100}$ F — $\left(1 - \frac{28h}{100}\right)$	Heat loss in unburned fuel. 100-41*e*
	Percent.	Percent.	Percent.	Percent.	Pounds.	Percent.
1	L	M	N	O	P	41*b*
521-A	*0.894*	*59.5*	*58.2*	*40.5*	*14.943*	*29.6*

APPENDIX Q/9.

LOCOMOTIVE:
TYPE . . . .
CLASS . . . .
NUMBER . . .

THE PENNSYLVANIA RAILROAD.
TEST DEPARTMENT.

COMBUSTION CALCULATIONS — FRY METHOD.

Report No. .....
Altoona, Pa., *3-10-3*

Test No.	Heat loss due to CO. $\frac{L \times 41e}{100}$	Heat loss in smoke-box gas. $\frac{K \times 41e}{100}$	Coal burned in percent of coal fired. $100 \times \frac{N}{O}$	Efficiency of		Air supplied per	
				Combustion.	Absorption. $\frac{N}{100 \times \frac{41f}{}}$	Pound of dry coal fired. $P \times \frac{41e}{100}$	Hour $33c \times$
	Percent	Percent	Percent	Percent	Percent	Pounds.	Pound
1	41*c*	41*d*	41*e*	41*f*	41*g*	41*h*	41*i*
521-A	*0.5*	*11.7*	*70.4*	*69.9*	*83.3*	*10.5*	*8010*

APPENDIX Q/10.

LOCOMOTIVE:
TYPE . . . .
CLASS . . . .
NUMBER . . .

THE PENNSYLVANIA RAILROAD.
TEST DEPARTMENT.

COMBUSTION CALCULATIONS — FRY METHOD

Report No. .....
Altoona, Pa., *3-10-3*

Test No.	Desig-nation.	Dry coal fired per hour.	Equiv. evap. per hour.	Heat balance				
				Efficiency of boiler.	Heat loss due to			
					External radiation.	Fuel escaping unburned.	Imperfect combustion producing CO.	Heat smoke gas
		Pounds.	Pounds.	Percent.	Percent.	Percent.	Percent.	Perce
1	1*a*	33*c*	37*b*	41	41*a*	41*b*	41*c*	41
521-A	*200-40-F*	*7617*	*60 296*	*55.4*	*2.8*	*29.6*	*0.5*	*11*

APPENDICES Q/11 to Q/14.—Forms used in the calculation of the heat balance for the boiler, with typical results. — Japanese Government Railways.

APPENDIX Q/11. — Calculation sheet on heat balance (1).

	Item.	Mark.	Example	
			Calorie/kgr. coal.	%
	Calorific value of coal.	H_2	7595	100
	Heat absorbed by boiler	H_{21}	5959	78.46
Heat losses	Heat carried away in the dry smoke-box gases	H_{24}	855	11.26
Heat losses	Evaporation of moisture in coal . .	H_{25}	62	0.82
Heat losses	Heat carried away by steam formed by the burning of hydrogen . . .	H_{26}	320	4.21
Heat losses	Heating moisture in air	H_{27}	23	0.30
Heat losses	Carbon monoxide.	H_{28}	0	0
Heat losses	Cinder.	H_{29}	318	4.19
Heat losses	Radiation from boiler	H_{30}	44	0.58
Heat losses	Unaccounted for	H_{31}	14	0.18

H_{24} $Cp_2 \times (T_8 - T_1) \times G_2$.

H_{25} $(W_1 + W_2 + W_4) \times (100\text{-}T_1) + 539.3 + Cp_1 \times (T_8\text{-}100)$

H_{26} $G_6 \times (100\text{-}T_1) + 539.3 + Cp_1 \times (T_8\text{-}100)$.

H_{27} $G_5 \times Cp_1 + (T_8\text{-}T_1)$.

H_{28} $5640 \times G_4$.

H_{29} $H_8 \times J_{15}$.

H_{30} $\dfrac{\text{Total radiation loss in calorie/hr}}{C_{12}} \times \dfrac{1}{H_{21}}$

APPENDIX Q/12. — Calculation sheet on heat balance (2).

	Item.	Mark.	Formula.	Example.
Weight kg./kg. coal	Carbon actually burned in coal	C_{33}	$C - C_{25}$	0.6918
Weight kg./kg. coal	Dry smoke-box gases . .		$\dfrac{4 \times CO_2 + O_2 + 700}{3\,(CO_2 + CO)} \times C_{33}$.	13.38
Weight kg./kg. coal	Air required for combustion	G_3	$G_2\text{-}C_{33} + 8\,(H + \dfrac{O}{8})$	13.21
Weight kg./kg. coal	Carbon monoxide . . .	G_4	$\dfrac{CO}{CO_2 + CO} \times C_{33}$.	0
Weight kg./kg. coal	Moisture in air required for combustion . . .	G_5	$G_3 \times \rho$	0.192
Weight kg./kg. coal	Water formed by burning of hydrogen	G_6	$9 \times H$	0.4572
	Weight of moisture in 1 cubic metre air in test condition (kgr.).	ρ	$\dfrac{1}{1.293} \times \dfrac{760}{P} \times \dfrac{273 + T_1}{273} \times \dfrac{h}{100} \times W_{35}$.	0.01454

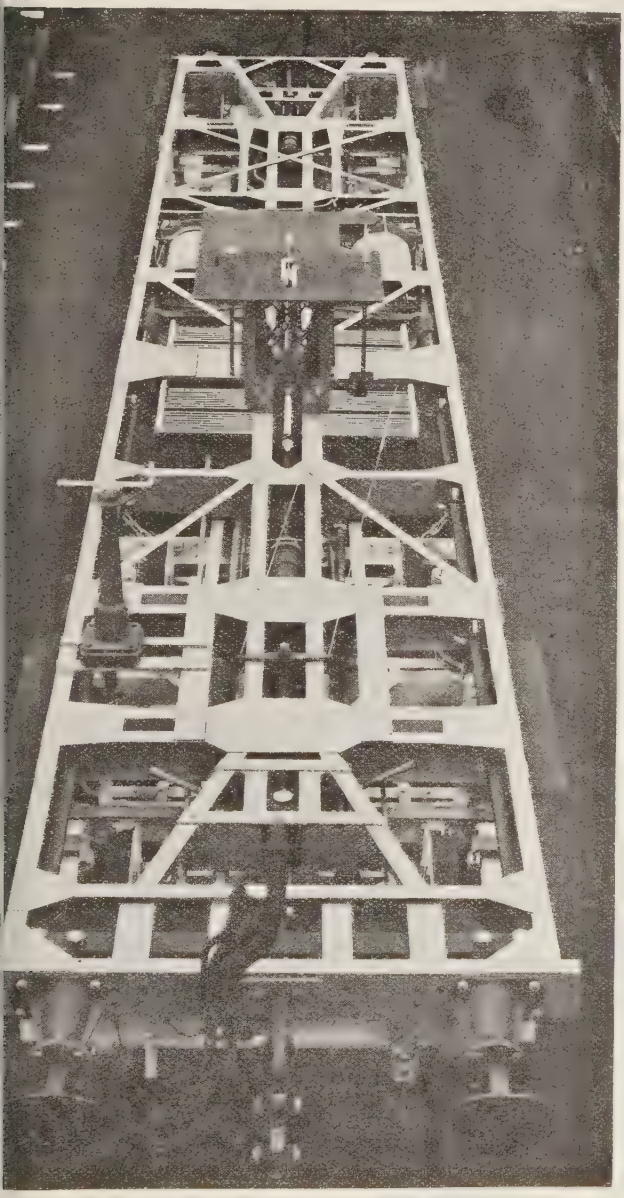
APPENDIX Q/13. — Calculation sheet on heat balance. — Japanese Govt. Rys. (3).

Item.		Mark.	Example.
Calorific value (calories)	Coal.	H_2	7595
	Cinder.	H_8	5054
Coal consumption (kgr.)	For test.	C_{12}	693.6
Water sprinkled to 1 kgr. coal.		W_4	5.48
Weight (kgr.)	Cinder.	J_8	43.7
Weight of constituents of coal %	Water.	W_1	1.28
	Moisture.	W_2	2.15
	Ash.	A_1	10.34
	Carbon.	C	73.23
	Hydrogen.	H	5.08
	Oxygen.	O	8.55
	Nitrogen.	N	1.52
	Sulphur.	S	0.20
Weight of combustion products (%)	Carbon in cinder.	C_{32}	64.41
Combustion production from 1 kgr. coal (kgr.)	Cinder.	J_{15}	0.0630
	Carbon in cinder.	C_5	0.0405
Weight (kgr./kgr. coal)	Dry smoke-box gases.	G_2	13.38
	Air for combustion.	G_3	13.21
	Carbon monoxide.	G_4	0
	Moisture in air for combustion.	G_5	0.192
Weight (kgr./kgr. coal)	Water formed by the burning of hydrogen.	G_6	0.4572
Dry products (kgr./kgr. carbon)		G_7	19.35
Constituents of smoke-box gases (%)	Carbon dioxide.	CO_2	13.05
	Oxygen.	O_2	5.05
	Carbon monoxide.	CO	0
	Nitrogen.	N_2	81.90

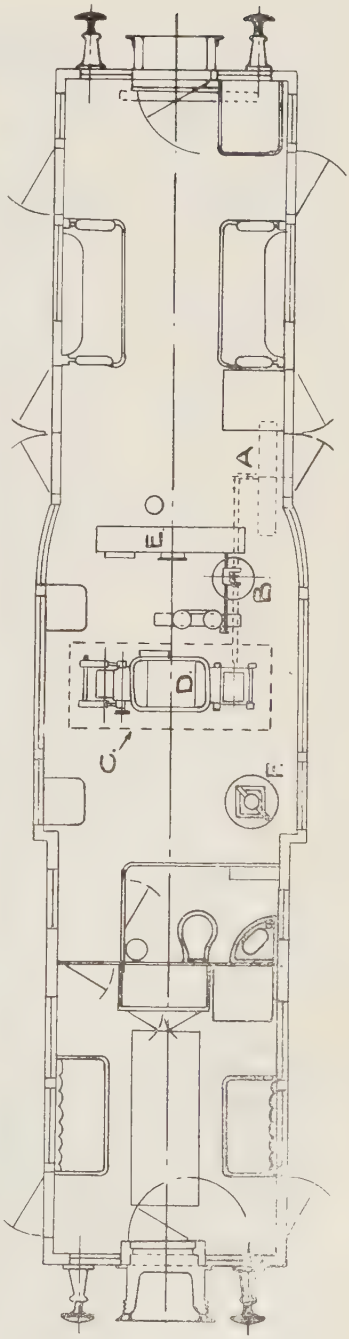
APPENDIX Q/14. — Calculation sheet on heat balance. — Japanese Govt. Rys. (4).

Item.		Mark.	Example.
Mean temperature (°C)	Testing room.	T_1	27.5
	Smoke-box.	T_8	291.6
Mean specific heat	Steam at atmospheric pressure	Cp_1	0.4615
	Smoke-box gases.	Cp_2	0.242
Relative humidity (%)		h	65.0
Atmospheric pressure mm./Hg.		P_1	759.25
Moisture in 1 cub. metre air saturated at room temperature (kgr.)		W_{35}	0.0263

PENDIX R/1. — Plan view of dynamometer car underframe, shewing instrument table and push and pull springs.
London, Midland and Scottish Railway.



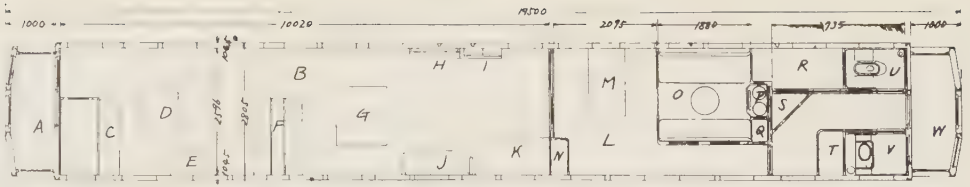
APPENDIX R/2. — Plan of lay-out in dynamometer car. — London and North Eastern Railway.

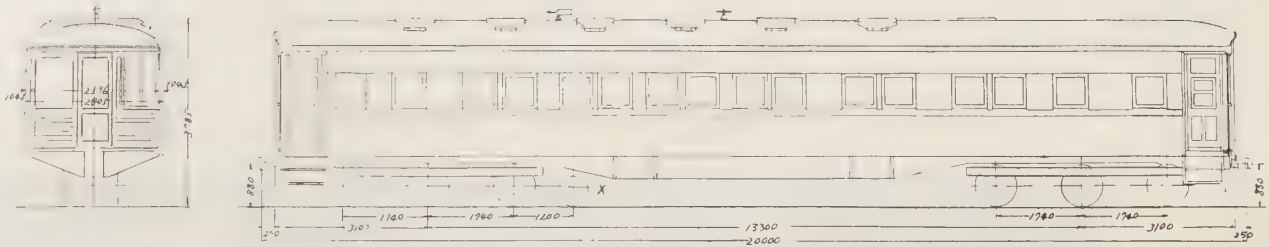


A Transmission wheel and shafting.
B Integrator.
C Traction spring.
D Recording table.
E Instrument table.
F Transmission wheel handle.

APPENDIX R/3. — Plan of lay-out and end and side elevations of new dynamometer car under construction.

Japanese Government Railways.

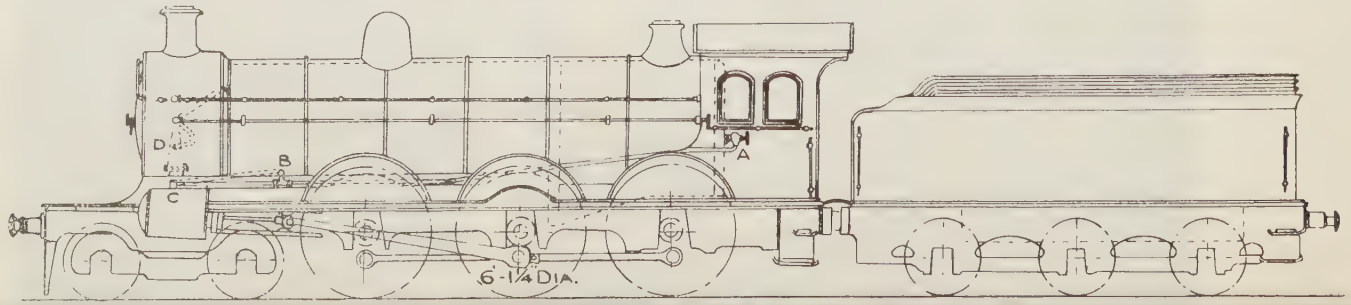




A Platform.
B Measuring room.
C Meter board for electric measuring instruments.
D Table for vibration recorder.
E Work bench.
F Gauge board for steam locomotive.
G Recording table.
H Switch board.
I Charging device.
J Bench.
K Flat top desk.
L Investigation room.
M Table.
N Book shelf.
O Resting room.
P Kettle.
O Book shelf.
R Outfit room.
S Locker.
T Locker.
U Lavatory.
V Toilet.
W Platform.
X Driving truck for recording table.

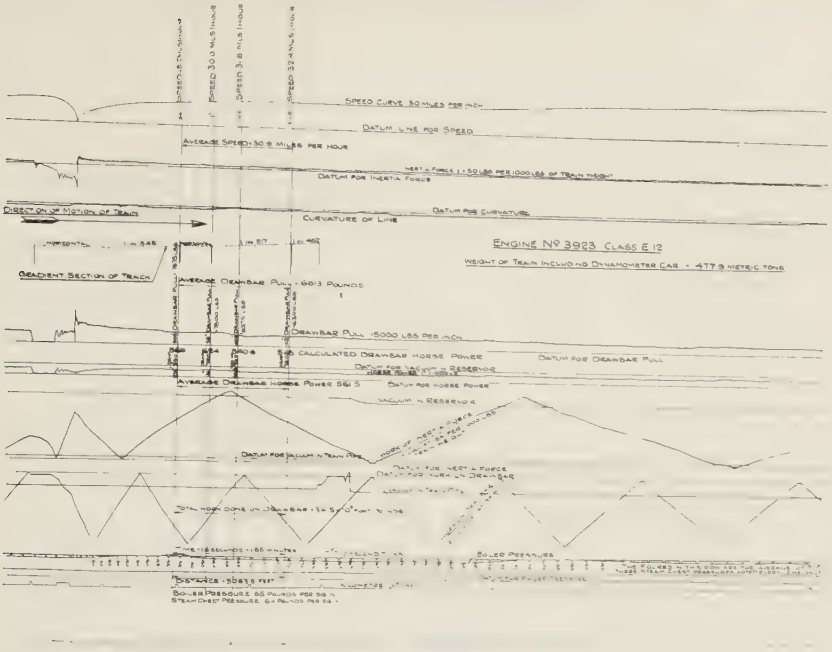
APPENDIX S/1. — 4-6-0 brake locomotive, with lay-out of steam and water pipes.

London and North Eastern Railway.

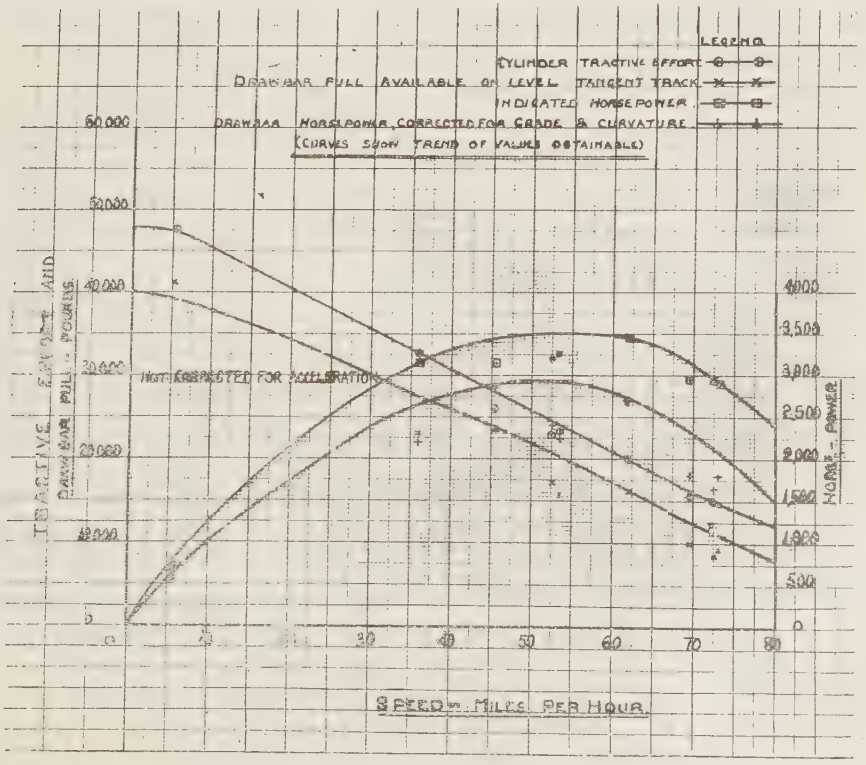


A Water injection valve.
C Water inlet to cylinder.

APPENDIX T/0. – Dynamometer car records of tests with express passenger engine No. 3923. Buenos Ayres Great Southern Railway.


SPEED CURVE 30 MILES PER INCH
DATUM LINE FOR SPEED
AVERAGE SPEED = 30·8 MILES PER HOUR
DATUM FOR INERTIA FORCE
DIRECTION OF MOTION OF TRAIN
CURVATURE OF LINE
DATUM FOR CURVATURE
ENGINE Nº 3923 CLASS E 13
WEIGHT OF TRAIN INCLUDING DYNAMOMETER CAR = 477·8 METRIC TONS
GRADIENT SECTION OF TRACK
AVERAGE DRAWBAR PULL = 6013 POUNDS
DRAWBAR PULL 15000 LBS PER INCH
CALCULATED DRAWBAR HORSE POWER
DATUM FOR DRAWBAR PULL
AVERAGE DRAWBAR HORSE POWER 561·5
DATUM FOR HORSE POWER
VACUUM IN RESERVOIR
DATUM FOR VACUUM IN TRAIN PIPE
DATUM FOR INERTIA FORCE
DATUM FOR WORK IN DRAWBAR
BOILER PRESSURE
BOILER PRESSURE 85 POUNDS PER SQ IN
STEAM CHEST PRESSURE 64 POUNDS PER SQ IN

APPENDIX T/1. — Characteristic (curve-drawbar pull and horse-power) for V.3 class engine No. 5350. — Baltimore and Ohio Railroad.



A

Performance (including indicating data) of V-3,

THE BALTIMO

Data and computation of indicator

Equipped with 10" double admission piston valves, Walschaerts valv
Maximum valve travel at 75 % cutt-off 7"; S
Rated boiler pressure 350 lb. per sq. in.; Diam
Diameter of piston rods 5.00"; .
Horse-power constants. WE

Right cylinder	
Left cylinder	

Location.	Grade, per cent.	Curve, degrees.	Speed, m.p.h.	Cut-off, per cent.	Steam pressure, lb. per sq. in.			
					Boiler.	Steam pipe.	Maximum initial.	Leas exhau
Leaving 63rd. St. Stn., Chicago	+0.23	3.0	5.4	75	310	300	300	3.0
0.80 mile east of So. Chicago.	+0.06	Tan.	36.0	40	340	320	310	12.0
Barnesville grade 35.00 miles west of Washington . . .	+1.04	1.5	45.5	25	350	345	320	12.0
Nine mile grade 91.35 miles west of Baltimore	+0.57	0.8	52.5	20	345	335	320	12.0
35.70 miles east of Chicago . .	−0.09	Tan.	53.5	30	310	295	290	12.0
43.40 miles east of Chicago . .	+0.34	Tan.	62.0	20	340	330	320	12.0
48.50 miles east of Chicago . .	0.0	Tan.	69.5	10	345	315	305	7.0
206.00 miles west of Willard.	0.17	Tan.	72.5	10	340	315	305	8.0
203.15 miles west of Willard.	0.02	Tan.	73.0	10	340	315	305	7.0

'/2.

gine No. 5350. — Baltimore and Ohio Railroad.

HO RAILROAD.

u.

on locomotive No. 5350, class V-3.

hauling train No. 6, Chicago to Washington, September 20 and 21, 1935.

1/16''; Lead 1/8''; Exhaust clearance 1/16'';

ers, right 22.55''; left 22.50''; Stroke 29'';

mference of main drivers 251.06''.

= M.E.P. × M.P.H. × C.

Head end.	Crank end.
0.12303	0.11697
0.12248	0.11642

team mp. g. F team ipe.	Mean effective pressure. Average lb. per sq. in.	Indicated horse-power.	Cylinder tractive effort, pounds.	Drawbar pull.		Draw-bar horse-power.	Mechanical efficiency, per cent.	Resistance of engine and tender.		
				Actual, pounds.	Available on level tangent, pounds.			Due to grade and curvature pounds.	On level (*) tangent track.	
									Pounds.	Pounds per ton.
560	264.6	684.1	47 508	39 200	41 215	593.5	Booster on.	+2 015	...	...
590	183.1	3 153.8	32 852	22 600	22 930	2 201.3	69.8	+ 330	9 922	36.1
500	144.6	3 148.9	25 952	17 300	23 400	2 839.2	90.2	+6 100	2 552	9.3
400	128.1	3 217.6	22 983	13 800	17 140	2 399.6	74.6	+3 340	5 843	21.3
500	128.7	3 293.7	23 087	16 200	15 705	2 240.6	68.0	— 495	7 382	26.8
410	115.8	3 435.2	20 777	14 500	16 370	2 706.5	78.8	+1 870	4 407	16.0
110	88.5	2 942.7	15 878	9 800	9 800	1 816.3	61.7	None.	6 078	22.1
190	84.7	2 939.2	15 203	9 500	8 565	1 655.9	56.3	— 935	6 638	24.2
190	83.5	2 916.7	14 983	9 400	9 290	1 808.5	62.0	— 110	5 693	20.7

ot corrected for acceleration.

APPENDIX T/3.

THE BALTIMORE AND OHIO RAILROAD COMPANY.

Test Bureau.

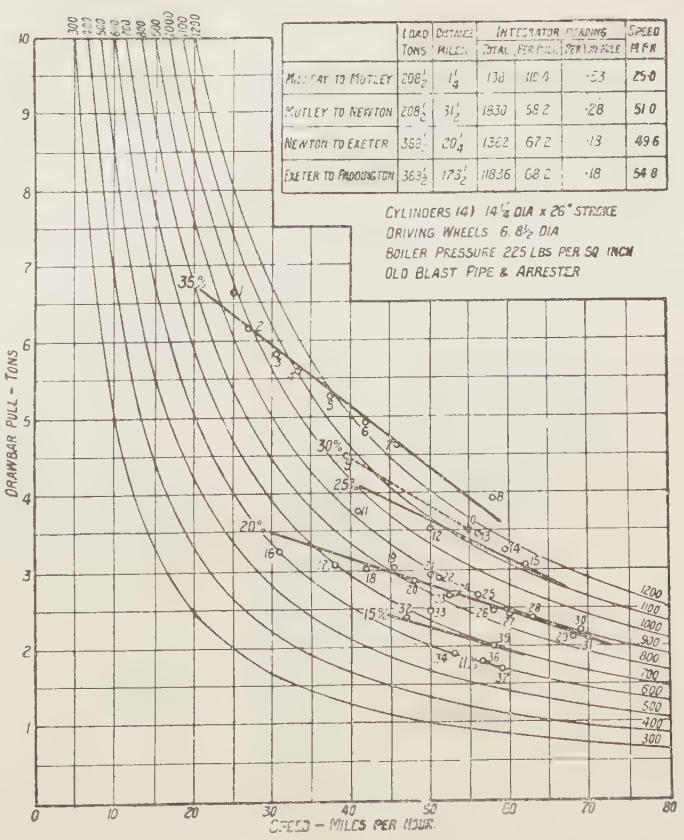
Full consumption test of locomotive No. 5350, class V-3,
equipped with 10" double admission piston valves, Walschaerts valve gear,
hauling trains Nos. 5 and 6 between Washington and Cumberland — September 21, 1935.

Locomotive		No. 5350, class V-3	
Test number (See note)		1	2
Date of test		September 21, 1935	September 21, 1935
Train number		6	5
From		Cumberland	Washington
To		Washington (F tower)	Cumberland
Miles	Total	144.55	151.55
	Pulling train	102.95	110.55
	Drifting	42.60	41.00
Weather		Clear	Clear/cloudy
Avg. temperature of atmosphere, deg. F.		65	85
Number of cars		10	11
Weight in tons	Behind locomotive	862.4	926.9
	Inc. loco. with tender 2/3 loaded	1 137.1	1 201.6
Time, minutes	Elapsed	166.0	175.8
	Pulling train	115.4	127.0
	Drifting	47.4	43.8
	Running	162.8	170.8
	Standing	3.2	5.0
Average speed, m.p.h.	Pulling train	53.53	52.23
	Running	53.64	53.24
	Inc. time standing	52.61	51.72
Average drawbar pull — pounds		10 379	14 041
Average drawbar horsepower		1 482	1 956
Drawbar horsepower-hours — working		2 850.4	4 140.2
Average cut-off, per cent		17.0	20.2
Average	Boiler	344.5	345.4

		65.5	68.5
Coal fired, pounds	Total	14 000	15 700
	Per hour elapsed	5 060	5 358
	Per hour pulling train	7 279	7 417
	Per mile	96.2	103.6
	Per 1 000 ton-miles — Behind locomotive	111.5	111.8
	Per 1 000 ton-miles — Including locomotive	84.6	86.2
	Per 1 000 lb. drawbar pull mile	13.10	10.11
	Per drawbar horsepower — hour working	4.91	3.79
	Per sq. ft. grate area per hour	83.77	90.45
Water, pounds	From tank	93 407	117 227
	In boiler at start minus at finish	—	—
	Overflow loss	600	400
	Blow-off loss	1 920	3 000
	Rail washer loss	0	0
	Sprinkler loss	80	400
Water evaporated, pounds	Total	90 807	113 427
	Per pound of coal as fired	6.49	7.22
	Per hour elapsed	32 822	38 712
	Per hour pulling train	47 213	53 588
	Per mile	523.9	748.4
	Per 1 000 ton-miles — Behind locomotive	723.4	807.5
	Per 1 000 ton-miles — Including locomotive	548.7	622.9
	Per 1 000 lb. drawbar pull mile	84.98	73.07
	Per drawbar horsepower-hour working	31.86	27.40
	Per sq. ft. water heating surface per hour	13.45	15.27
Steam, pounds	Saturated — Used by auxiliaries	6 357	7 940
	Saturated — Used by steam heat	0	0
	Saturated — Lost at safety valve	—	—
	Superheated (to cylinders) — Total	84 450	105 487
	Superheated (to cylinders) — Per drawbar — horsepower — hour working	29.63	25.48
Heat transfer, 1 000 BTU	Across water heating surface	105 788	132 019
	Across superheating surface	7 972	10 971
	Total	113 760	142 990
Equivalent evaporation, pounds	Total	117 230	147 352
	Per pound of coal as fired	8.37	9.39
	Per sq. ft. comb. htg. surface per hour	13.98	15.97
Coal analysis	Moisture, per cent	0.30	0.20
	Heating value BTU. per lb. — Coal as fired	13 423	13 452
	Heating value BTU. per lb. — Dry coal	13 463	13 479
Efficiency of boiler, per cent		60.54	67.70

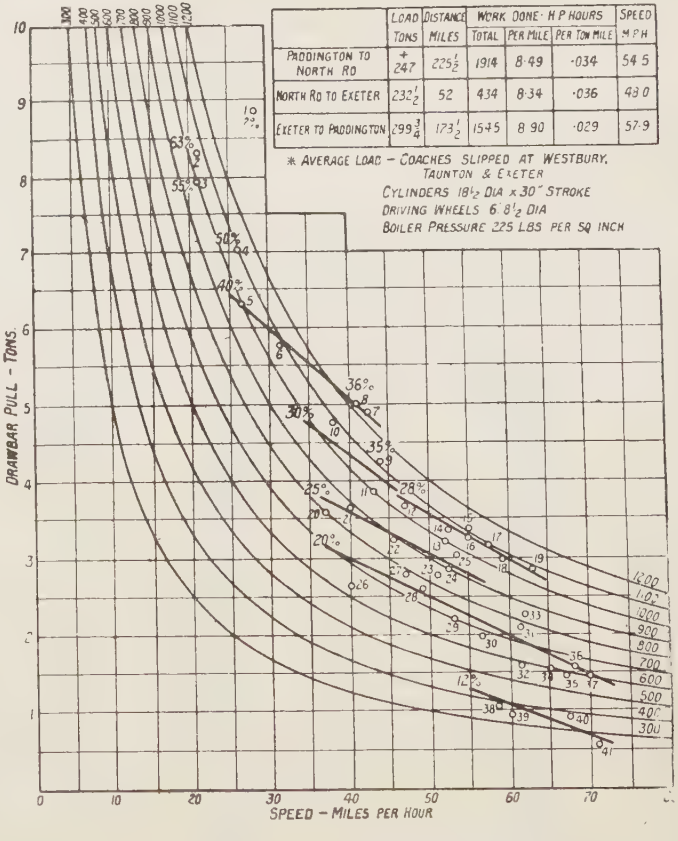
NOTE. — Used 7 1/2" diameter exhaust nozzle with Goodfellow four lug ring superimposed on both tests.

APPENDIX T. 4. – Characteristic curves of drawbar pull and speed for four-cylinder and two-cylinder 4-6-0 « Castle » class engines. Great Western Railway.


DRAWBAR PULL - TONS
SPEED - MILES PER HOUR
CYLINDERS 14) 14⅛ DIA x 26" STROKE
DRIVING WHEELS 6. 8½ DIA
BOILER PRESSURE 225 LBS PER SQ INCH
OLD BLAST PIPE & ARRESTER

	LOAD TONS	DISTANCE MILES	INTEGRATOR READING TOTAL	INTEGRATOR READING PER MILE	INTEGRATOR READING PER TON MILE	SPEED M.P.H.
MIDDAY TO MOTLEY	206½	1¼	130	110·4	·53	25·0
MOTLEY TO NEWTON	208½	31½	1830	58·2	·28	51·0
NEWTON TO EXETER	363	20¼	1362	67·2	·13	49·6
EXETER TO PADDINGTON	363½	173½	11836	68·2	·18	54·8

Characteristic Curve" for Four-Cylinder 4-6-0 Type Engine.


DRAWBAR PULL - TONS
SPEED - MILES PER HOUR
CYLINDERS 18½ DIA x 30" STROKE
DRIVING WHEELS 6. 8½ DIA
BOILER PRESSURE 225 LBS PER SQ INCH

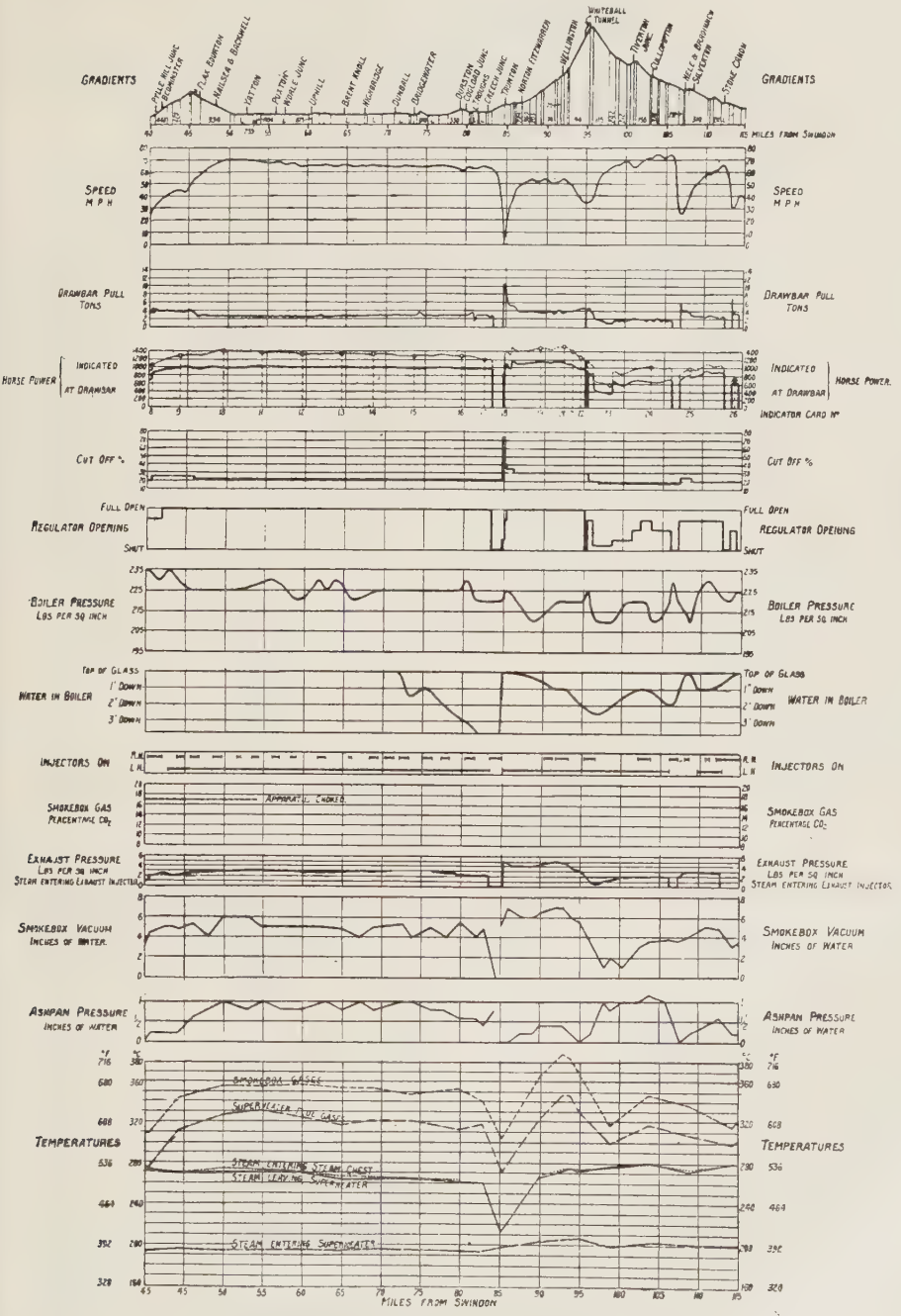
	LOAD TONS	DISTANCE MILES	WORK DONE - H.P. HOURS TOTAL	WORK DONE - H.P. HOURS PER MILE	WORK DONE - H.P. HOURS PER TON MILE	SPEED M.P.H.
PADDINGTON TO NORTH RD	+ 247	225½	1914	8·49	·034	54·5
NORTH RD TO EXETER	232½	52	434	8·34	·036	43·0
EXETER TO PADDINGTON	299¾	173½	1545	8·90	·029	57·9

* AVERAGE LOAD – COACHES SLIPPED AT WESTBURY, TAUNTON & EXETER

"Characteristic Curve" for Two-Cylinder 4-6-0 Type Engine.

(Reproduced by permission of *The Railway Gazette*).

APPENDIX T/5. — **Curves indicating performance obtained on test with « Castle » class engine.** — Great Western Railway.



Curves Indicating Performance on Trial Run of "Castle" Class Engine, G.W.R.

(Reproduced by permission of *The Railway Gazette*).

APPENDIX T/6. — Particulars of information taken during power and consumption trials.
London, Midland and Scottish Railway.

DYNAMOMETER CAR TESTS: ENGINE No. . . .

Route	
Schedule	
Date	
Weight of engine and tender, 2/3 coal and water . . . . . tons.	
Weight of train behind drawbar, including dynamometer car, tons.	
Weight of train, including engine . . . . . tons.	
Train-miles	
Ton-miles (excluding engine)	
» (including engine)	
Running time (actual) . . . . . mins.	
» (including stops) . . . . . mins.	
Average running speed . . . . . m.p.h.	
Maximum running speed . . . . . m.p.h.	
Work done by engine in H.P./hours	
» » H.P./mins	
H.P./minutes per ton-mile (excluding engine)	
Coal:	
Total weight in lb.	
Lb. per mile	
Lb. per ton-mile (excluding engine)	
Lb. per drawbar-H.P./hour	
Lb. per sq. ft. grate per hour	
Water:	
Total gallons used	
Gallons per train-mile	
Lb. per ton-mile (including engine)	
Lb. per drawbar-H.P./hour	
Lb. per lb. of coal	

APPENDIX T/6 (I). — **Particulars of information taken during power and consumption trials.**
London and North Eastern Railway.

DYNAMOMETER CAR TEST DATA. ENGINE No. . . BOILER PRESSURE . . . .

Date		
Train		
Weight of engine, 2/3 coal and water . . . . . tons.		
Weight of train with dynamometer car . . . . . tons.		
Total weight of engine, car and train . . . . . tons.		
Train-miles		
Ton-miles (excluding engine)		
Ton-miles (excluding engine), 10 % added for passengers and luggage		
Ton-miles (including engine)		
Ton-miles (including engine), 10 % added for passengers and luggage		
Running time . . . . . minutes.		
Time including stops . . . . . minutes.		
Average speed . . . . . miles per hour.		
Maximum speed . . . . . miles per hour.		
Average drawbar pull . . . . . tons.		
Total work done by engine in horse-power/minutes		
Total work done by engine in horse-power/hours		
Average drawbar horse-power		
Maximum drawbar horse-power		
Horse-power/hours per train-mile		
Horse-power/minutes per ton-mile (excluding engine)		
Horse-power/minutes per ton-miles (excluding engine), 10 % added		
Water:		
Gallons consumed		
Gallons per mile		
Pounds per ton-mile (including engine)		
Pounds per ton-mile (10 % added)		
Pounds per drawbar horse-power/hour		
Pounds per sq. ft. of evaporative heating surface/hour		
Coal:		
Weight burned . . . . . pounds.		
Pounds per mile		
Pounds per ton-mile (excluding engine)		
Pounds per ton-mile (excluding engine), 10 % added.		
Pounds per ton-mile (including engine)		
Pounds per ton-mile (including engine), 10 % added		
Pounds per drawbar horse-power/hour		
Average per sq. ft. of grate area per hour . . pounds.		
Evaporation:		
Pounds of water per pound of coal		

APPENDIX T/7. — Brief summary of types of test made.

London, Midland and Scottish Railway.

Determination of general efficiency of two types of engine.

Both engines are supplied with similar coal, and if of equivalent rated power, haul identical loads over the same route.

Determination of effect of acceleration in timing.

Particulars obtained of the engine performance with a given load to the existing timings, and subsequently when running to the altered timings. The results are then compared.

Determination of efficiency of a special feature, fitting, etc.

Series of tests made with the same engine alternatively with special fitting in use and not in use, other conditions of test being similar.

Determination of effect of alteration in efficiency due to the length of time in service of the engine.

As far as possible conditions are kept comparable and testing is carried out at intervals between general repairs.

Determination of train resistance.

The dynamometer car is reversed, and a series of tests made in which work done by engine on train, and by train on engine, or in the case of a purely coasting test, the work done by the train on the dynamometer car, is measured.

Determination of effect of operation with varying types of coal.

The same engine works the same load over the same route with different classes of coal. All particulars are taken of consumptions as mentioned in connection with previous tests, and results are compared.

APPENDIX T/7 (I). — Brief summary of types of test made.

London and North Eastern Railway.

Full performance trials of a new type of engine.

The information is compiled under headings shewn in Appendix T/6 (1), and in addition steam temperatures and pressures, smokebox gas analyses and indicator diagrams are taken.

Comparative performance tests between two types of engine.

These tests are usually run with alternate engines on regular booked trains daily, for a week or longer. Conditions are kept as comparable as possible (i. e. coal supplied, load, route, etc.).

Time and load rating of train to determine the effect of acceleration and increased load.

The train is run to the booked schedule first, and the power output required taken. A similar trial is then made at the accelerated timings to find the additional output necessary. Similar trials for loading are made when required.

Trials of special fittings.

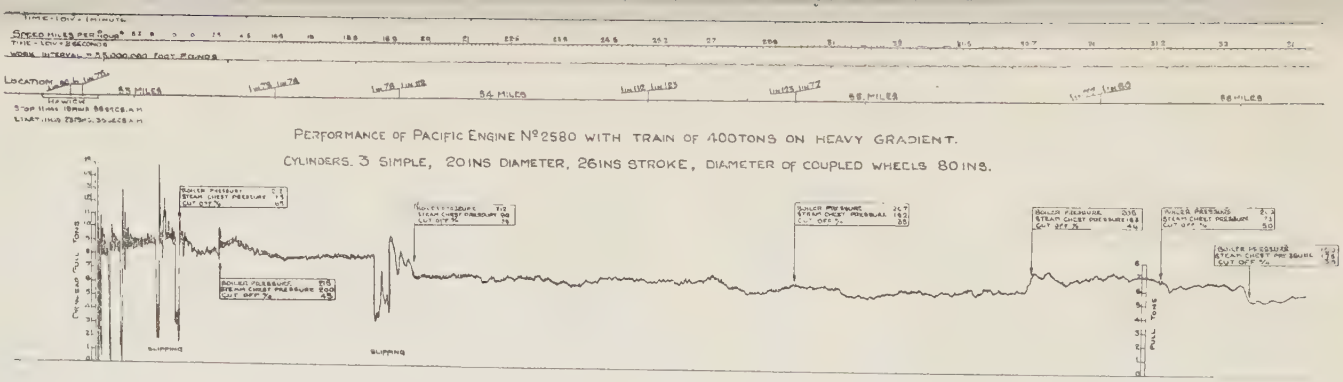
In general these trials are made on the same engine with and without the special fitting in use. Occasionally two engines of similar type are employed and one is equipped with the special fitting. Conditions are kept as comparable as possible.

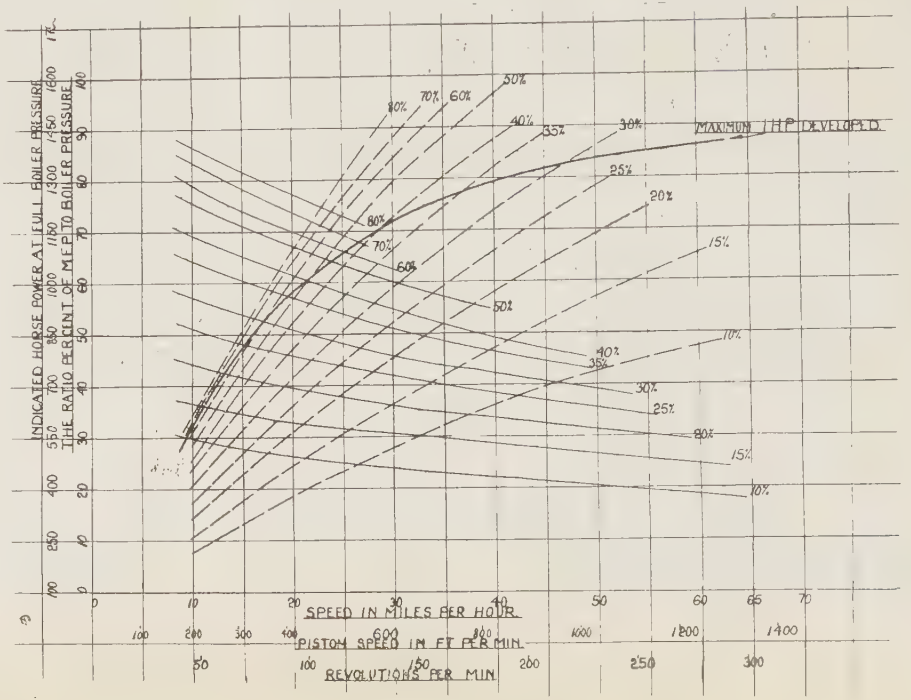
Brake tests.

The accurate records necessary to obtain a reliable retardation curve can only be obtained with the dynamometer car. Particulars are taken of the speed, the moment of brake application on the engine and the distance and time taken to stop.

Train resistance tests.

For a comparison of rolling stocks, a level section of line is selected and the trials run at a predetermined speed. Particulars of the work done by the engine on the train are taken. The trials are run on the same day when possible to eliminate variation in weather conditions, etc.

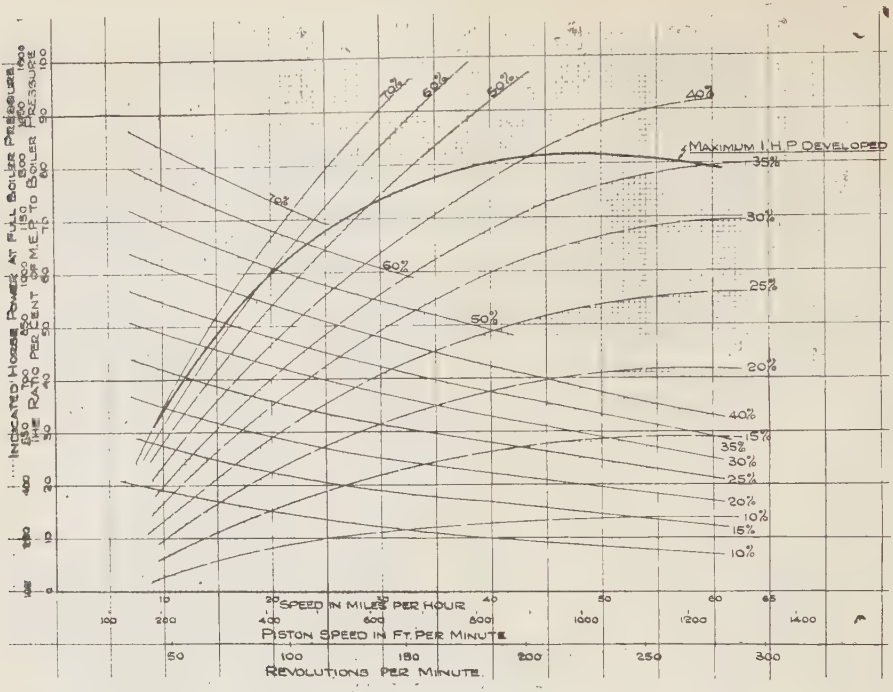

PERFORMANCE OF PACIFIC ENGINE Nº2580 WITH TRAIN OF 400TONS ON HEAVY GRADIENT.
CYLINDERS. 3 SIMPLE, 20INS DIAMETER, 26INS STROKE, DIAMETER OF COUPLED WHEELS 80INS.
SLIPPING
SLIPPING


INDICATED HORSE POWER AT FULL BOILER PRESSURE
THE RATIO PER CENT OF M.E.P. TO BOILER PRESSURE
MAXIMUM I.H.P. DEVELOPED
SPEED IN MILES PER HOUR
PISTON SPEED IN FT PER MIN.
REVOLUTIONS PER MIN

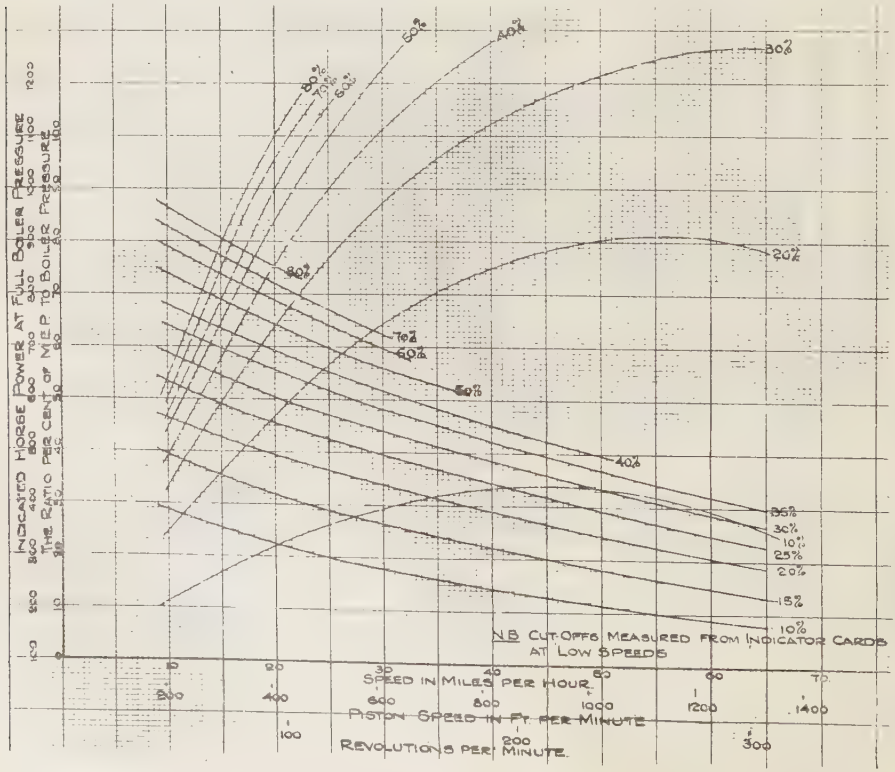
APPENDIX T/9. — Cylinder performance at varying speeds and cut-offs, D.4 engine, Caprotti valve gear.

Great Indian Peninsula Railway.

APPENDIX T/10. — **Cylinder performance at varying speeds and cut-offs, D.5 engine, Walschaerts valve gear.** — Great Indian Peninsula Railway.



APPENDIX T/11. — **Cylinder performance at varying speeds and cut-offs, E. I. Ry, engine No. 252.** — Great Indian Peninsula Railway.



APPENDIX T/12.— Example of performance tests carried out.—Japanese Government Railways.

Date of test		May 18, 1936.
Train number		1 900.
Test track section		Tosu-Moji (Kagoshima-line).
Locomotive number		C 5513.
Kind of test		Performance.
Average steam pressure (kgr./cm²).	Exhaust passage	0.1059
	Steam chest	12.23
	Boiler	13.28
Average draft (cm. of H_2O).	Smoke-box	7.755
Average temperature (°C).	Superheated steam	267.6
	Smoke-box gas	268.2
Consumption (kgr.).	Coal as fired	996.0
	Dry coal	969.9
	Evaporated water	7 615
	Water for auxiliary	251
	Water for engine	7 364
Consumption (kgr./h.).	Coal as fired	733.4
	Dry coal	714.1
	Evaporated water	5 630
	Water for engine	5 423
Rate of combustion kgr./m² of grate/hr.		289.9
Evaporative power (kgr./kgr. coal).	Coal as fired	7.65
	Equivalent	9.32
Boiler efficiency (%)		71.48
Smoke-box gas analysis (%).	CO_2	12.90
	O_2	5.43
	CO	0.30
	N_2	81.37
	Excess air	32.52
Time (min. sec.).	Running	113 — 05
	Powering	81 — 29
	Ratio (%)	72.06
Distance (km.).	Total	108.052
	Powering	76.387
	Ratio (%)	70.70
Weight of train (ton)		304.54
Average speed (km./hr.).	Total	57.33
	Powering	56.05
Car ton-km.		32 906
Average draw-bar pull (kgr.)		1 600
Average draw-bar H.P.		333.3
Work done (ton-km.)		122.22
Consumption per 100 ton-km. (kgr.) (vehicle).	Coal as fired	3.027
	Dry coal	2.943
	Water	23.14
Consumption per draw-bar H.P. (kgr./hr.).	Coal as fired	2.200
	Dry coal	2.142
	Water	16.27
Consumption per ton-km. (kgr.) (work done).	Coal as fired	8.149
	Dry coal	7.935
	Water	60.26

APPENDIX T/13. — Example of running resistance and mechanical efficiency tests carried Japanese Government Railways.

Date of test: May 18, 1936; Train number: 1900.
Weight of locomotive: 107.6 tons.
Test number: 11.
Test track section: Akama-Ebitsu (Kagoshima-line).
Km.-post: 44 km.
Gradient: 1 in 100 (up).
Weather condition: fair.
Air temperature: 24° C.
Atmospheric pressure: 759.8 mm./hg.

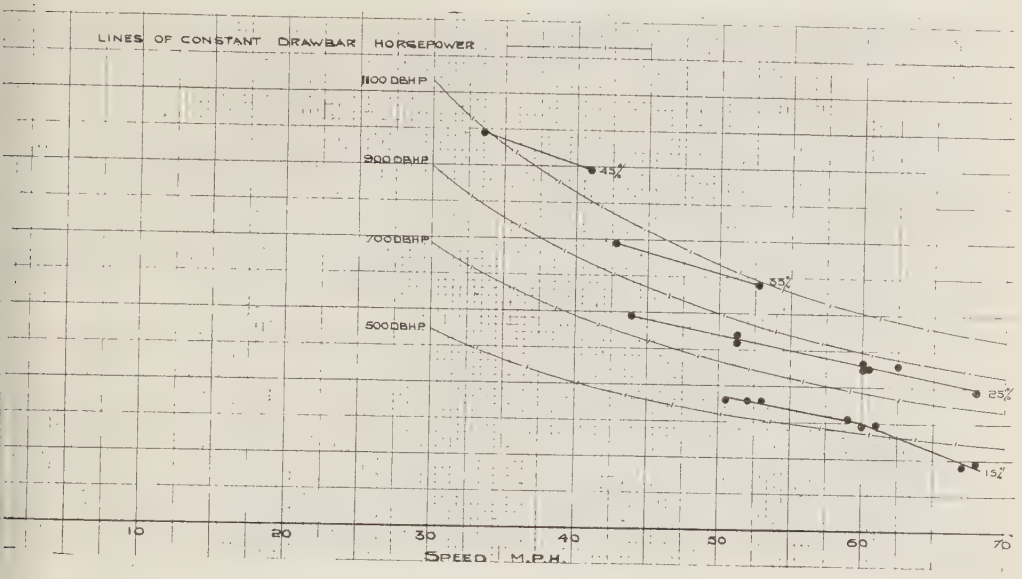
Pressure (kgr./cm²).	Boiler	13.
	Steam chest	13.
	Mean effective	4.
Train speed (km./hr.)		52.
Acceleration (km./hr./sec.)		0.
Indicated tractive force (kgr.)		4 684
Draw bar pull (kgr.).	Measured	2 970
	Corrected	3 917
Locomotive resistance (kgr.)	Total	767
	Per ton	7.
Mechanical efficiency (%)		83.

APPENDIX T/14. — Examples of train resistance test carried out. Japanese Government Railways.

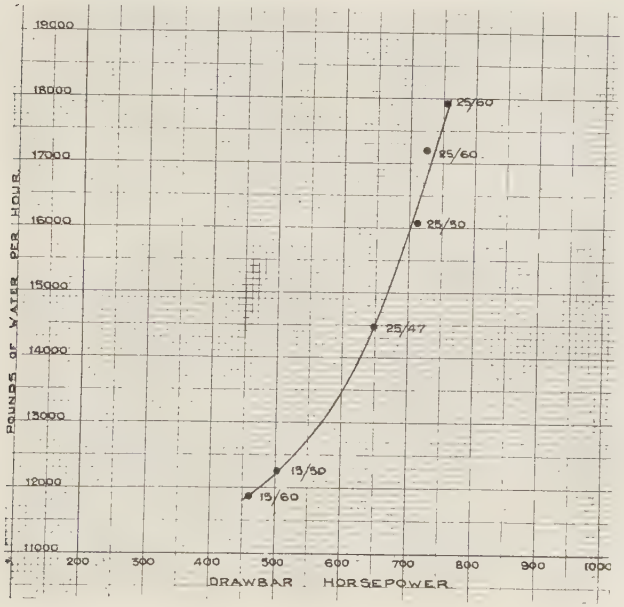
Date of test: Sept. 23, 1930.
Number of cars of the train: 9.
Weight of the train: 238.33 tons.
Test number: 13.
Test track section: Tsujido-Chigasaki (Tokaido trunk line).
Track condition: level and straight.
Weather condition: fair.
Air temperature: 29° C.
Atmospheric pressure: 760 mm./hg.
Wind velocity: 0.
Train speed: 73.17 km./hr.
Acceleration: 0.09756 km./hr./sec.

Resistance (kgr.).	Measured	1 732
	For acceleration	699
	For gradient	0
	Corrected	1 015
Net resistance		4.25 kgr

APPENDIX U/1. — Relation between maximum drawbar pull and speed at different cut-offs 4-4-0, three-cylinder locomotive on power test. — London and North Eastern Railway.



APPENDIX U/2. — Relation between hourly water consumption and drawbar H.P., 4-4-0 three-cylinder engine.
London and North Eastern Railway.



(See Conclusions on following page).

CONCLUSIONS.

The following general conclusions are drawn from an examination of the replies received from the various Railways to the detailed questionnaire :

PART ONE.

1. Steam pressures in general on engines of the usual types shew no marked increase. The comparatively small amounts by which the pressures have been raised have not resulted in any difference being reported on maintenance costs or life of the tubes.

2. Evaporation has been improved and fuel consumption reduced by the adoption of softened locomotive feed waters.

3. With treated waters, the use of continuous or intermittent blow-down have been adopted by some Administrations with a view to preventing priming. With this arrangement it is claimed that periods between washing-out have been lengthened with resultant economy.

4. There is a general increase in the air space through the grate, the maximum ratio of air space to grate area reported being 60 %. This figure represents an increase of from 20 % to 30 % on previous ratios.

5. The use of steam jet tube blowers has in many cases resulted in deterioration of tubes and tube plates. Sand guns operated by a steam jet are claimed to be an efficient means of cleaning tubes without the disadvantage of deterioration in the firebox.

6. Superheating temperatures generally shew no marked increase, but the trials with elements extended in length towards the firebox, and with trifurcated elements, have shewn an increase in the temperatures of superheated steam obtained.

7. Feed water heaters shew a definite fuel saving when compared with exhaust and live steam injectors, but in most cases this saving is neutralised by the increased cost of maintenance.

8. No new air preheating arrangements have been tested or applied to any of the locomotives dealt with in this report, since 1930.

9. Double blast pipes and chimneys have reduced back pressure, and progress has been made with the problem of lifting the smoke clear of the boiler by modification of the front end of the smoke-box.

10. Analysis shews that in piston valve engines the diameter of the valve is approximately half that of the piston.

11. The special sectional piston rings in use on the American Railways prevent any contact taking place between the piston head and the cylinder walls when the rings wear, which is an important factor in the lengthening of cylinder life. The practice in other countries appears to be mainly confined to cast iron or cast steel piston heads with one or two narrow rings, but the life of piston rings does not appear to have been greatly improved.

12. There is a general tendency to increase the diameter of pipes and passages forming the steam circuit, to prevent loss of pressure between the boiler and the steam chest.

13. Streamlining shews a definite saving in the horse-power required to overcome head-on air resistance at high speeds.

14. Greater use is being made of alloy steels. The reports indicate that improved mechanical properties and weight reduction in the reciprocating parts is obtained.

Light alloys are used to a limited extent, but no conclusions can be drawn as to their continued use.

PART TWO.

1. The 4-6-2, or *Pacific*, is the most generally adopted of the new types of engine built; the tractive effort and adhesion factor of this wheel arrangement are particularly suited to meet the modern tendency for increasing the average running speeds of main-line express passenger trains without reduction of load.

2. 325 lb./sq. in. appears to be the highest pressure desirable with the orthodox type of boiler. With pressures in excess of this figure it is desirable to adopt a water-tube firebox.

3. With one exception, compound engines are not to be found amoungst the new types built.

PART THREE.

1. The extension of the capacity of existing testing plants is contemplated, or is already in progress, to meet the demands of present-day testing.

The capacity of the dynamometer, the number of braked rollers, and the extent to which power can be absorbed by the brakes are the main details affected.

2. Lever dynamometers on stationary plants are satisfactory only when the reciprocating parts are completely balanced.

3. Hydraulic dynamometers are fitted in the most recent dynamometer cars built.

4. Stationary plant testing is more accurate and better suited for determining the effect of changes in design, whilst a strictly uniform basis is ensured for comparative trials.

5. Stationary plant testing should be implemented by trials on the line for determination of the capacity, efficiency and behaviour of the locomotive under working conditions.

6. Testing with brake-locomotives in conjunction with a dynamometer car is the most accurate way of testing engines on the line. It enables the conditions of load and speed to be controlled more exactly and to be repeated as often as required.

* * *

ACKNOWLEDGMENT.

The Reporter desires to acknowledge the information so readily supplied by the various Railway Companies, Railway Contractors and the Technical Press.

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

13th SESSION (PARIS, 1937).

QUESTION I.

The construction of modern track to carry heavy loads at high speeds, and methods of modernising old track for such loads and speeds.

Facing points which can be taken at high speeds.

REPORT

(Bulgaria, Egypt, Spain, France and Colonies, Greece, Italy, Portugal and Colonies, Rumania, Czechoslovakia, Turkey and Jugoslavia),

by H. FLAMENT,

Ingénieur en chef adjoint des Travaux et de la Surveillance,
Compagnie du Chemin de fer du Nord (France).

FOREWORD 1448/2

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Foreword.

The conditions under which modern permanent way should be constructed has become of quite special interest in recent years.

The railway track has not only to meet a constant increase in the weight of locomotives, carriages and wagons; but also to allow for greatly increased speeds, first of all run by fast and relatively light units such as railcars, but subsequently by steam trains hauled by up to date locomotives of suitable types.

As is known, there has been a steady increase in axle loads for a long time. This increase is the natural result of the progress in railway equipment providing more powerful locomotives, more comfortable passenger vehicles, and higher capacity wagons. Maximum train weights have risen in fifty years from 500 to 2 500 tons and the horse-power of the locomotives from 500 to 3 000.

The track ought to be in condition to carry the traffic as altered by these new circumstances which as regards tonnage approach the maximum loading per unit of length for which many structures were designed.

This is not all : for about half a century the fastest trains, with few exceptions, never exceeded 120 km. (75 miles) an hour. The introduction of railcars with modern internal combustion engines made possible much higher speeds than those reached formerly.

Modern steam or electric locomotive-

will doubtless be available in the near future, running at the speeds now allowed in the case of railcars, namely 150 km. (93 miles) an hour.

It is the problem set by these very high speeds and heavy loads which under present-day conditions governs railway traffic on the main lines of the large railway systems.

The object of the present report is to investigate the conditions to be fulfilled when building new railways or modernising existing lines in order to meet these desiderata and designing points which can be taken at high speeds.

We wish to thank here all the Railways who sent the information required to complete this report and to enable us to explore a subject which competition and other new traffic conditions have placed in the foreground of the questions which railway operators have to bear in mind.

* * *

PART ONE.

The construction of modern track to carry heavy loads at high speeds and methods of modernising old track for such loads and speeds.

CHAPTER I.

Characteristics of present-day vehicles.

The characteristics of a vehicle as regards the load it imposes on the track over which it runs are of different kinds. At the present time they cannot all be determined exactly.

Some of them are well known and their effects can be calculated.

These include the static loads on the axles transmitted to the track through the wheels, the sole contact the vehicle makes with the rails, and the geometrical inscription of the wheels on curves.

Others, dynamic in nature, especially noticed at high speeds, are still little known, are difficult to figure, or are even unsuspected.

These are, when a vehicle is in motion, the conditions of contact between the wheels and rails, and the various reactions, especially when running over the joints, the general equilibrium of the vehicles at high speeds, the proneness of the vehicle to irregular movements, such as hunting or nosing, the tangentical forces between the tyres and the rails when starting or applying the brakes; or again the reactions of the accessory fittings, such as the couplings between the vehicles, locomotives, carriages, wagons, etc.

This first chapter contains the information the railways have sent us, or which we have collected on the subject.

Vertical loads imposed by the vehicles on the track.

a) Axle loads.

The information in Table 1 is that received in reply to the following question:

What are the present maximum axle loads of the different classes of vehicle: steam locomotives, electric locomotives, high-capacity goods wagons, railcars, passenger carriages and other vehicles?

Should these axle loads be increased and to what extent?

The information collected can be summarised as follows:

The maximum axle loads of the present stock on the main lines of the railways consulted is as a rule 20 t. (19.7 Engl. tons) for steam and electric locomotives, and 18 t. (17.7 Engl. tons) for high-capacity goods wagons.

These figures are exceeded on some lines, however. The axle load on the *French Nord* is 21.5 t. (21.2 Engl. tons) in the case of the latest suburban engines,

Maximum axle loads (in metric tons) allowe

(In metric tons —

ADMINISTRATIONS.	Steam locomotives.	Electric locomotives.	High-capacity goods wagons.	Railcars.
Bulgarian State.	17	...	15	10.5
Egyptian State	18.8	...	13	14.5
Northern of Spain. (1.674 m. = 5′ 6″ gauge).	18	18.7	16.2	13.5
Madrid, Saragossa and Alicante (1.674 m. = 5′ 6″ gauge).	22 (1)	...	16 (1)	12.95
Western of Spain (1.674 m. = 5′ 6″ gauge).	22	...	18	...
Alsace-Lorraine	20 (2)	...	20 (2)	Maximum load n less than tha the locomot
French Est	21.0 on some lines only. 18.5 everywhere	...	18 on some lines only. 16 everywhere.	16 (3)
French State	20.08	16.2	16	12
French Nord	22 (21.5)	...	22 (20.125)	22 (16.965)
Paris-Lyon-Méditerranée (P.L.M.)	19.9	19	18	13.5
P.O.-Midi (France).	19.1	20	17.8	19.062
Algerian Rys.	18.5	20	16	...
Tunisian Rys. Standard gauge Metre gauge.	16.5 12	...	16.5 11.5	12 (under tria 10 (do.)
Colonial Rys. in French West Africa. (Metre gauge) .	11	...	8.95	...
Portuguese Railways (1.665 m. = 5′ 5 9/16″ g.)	16.8	...	14.25	...
Mozambique Rys.	16	...	15.5	6.4
Rumanian State.	20	...	20	14.5
Czechoslovak State	17.4	16.9	15	15.5
Turkish State	17.7	...	...	8
Jugoslav State	18	...	15	18 (11)

›resent by the various railways.

).984 Engl. ton).

ssenger riages.	Various vehicles, breakdown equipment, etc.	Contemplated increased.	Remarks.
13.5	...	None.	...
12	...	None.	...
13	...	Possibly up to 24 t.	...
11.85	...	None.	These loads are the axle loads of the standard train provided for in official instruction of the 24-10-25. The actual loads are much smaller.
16	...	None.	...
13	...	None.	These loads are the axle loads of the standard train defined by ministerial circular of the 10-5-27.
16 (3)	...	Locomotives 22 t.	These loads are not reached in practice.
16	...	Electric locomotives on the Paris-Le Mans line 20.2 t. (under construction).	...
22 (14.25)	(Travelling crane) 21.725)	None.	The figures between brackets are the maximum loads of existing vehicle.
15.5	...	...	...
13.75	(Travelling crane) 17.7	22 t.	...
10.25	...	None.	...
16.5 1.5	...	None.	...
5.9	(Travelling crane) 10.5	Diesel-electric locomotive : 12 t.	...
4.25	...	Locomotives : 20 t.	...
9.5	...	None.	...
5	...	None.	...
4.5	...	Locomotives : 20 t. Other stock : 16 t.	...
...	...	None.	...
5 (13.1)	...	....	The figures between brackets are the maximum loads of existing vehicle.

and 22 t. (21.7 Engl. tons) for certain new designs. A number of railways have goods wagons with 20 t. or slightly over per axle.

In the case of railcars and passenger vehicles, the axle load rarely exceeds 14 t. (13.8 Engl. tons) for vehicles of which there are a number in current use on the various Systems.

The heaviest axle loads on the railways consulted are :

— 21.5 t. (21.2 Engl. tons) : Steam locomotives (*Mikado* suburban engines of the 4-1200 class of the *French Nord*) ;

— 20 t. (19.7 Engl. tons) : Electric locomotives (2D2 of the *Paris-Orléans* (P.O.) and BB of the *Midi*) ;

— 21.125 t. (20.8 Engl. tons) : Goods wagons (*French Nord* well wagons) ;

— 19.06 t. (18.7 Engl. tons) : Electric suburban railcars of the *P.O.-Midi Railways*) ;

— 16.965 t. (16.7 Engl. tons) : *French Nord* Sentinel steam railcars;

— 16 t. (15.7 Engl. tons) : Passenger carriages (*French State* double-decker all-metal suburban coaches).

Out of the 18 railways consulted, 7 have under consideration an increase in the allowed axle loads, and some Administrations intend to admit engines, at least the first of a new type, with 22-t. (21.7 Engl. tons) axle loads.

The *French Nord* has taken advantage of the 10 % allowance provided for in the latest Ministerial regulations dated the 10th May 1927, on which the calculation and design of bridges and structures is based, to allow axle loads of 22 t. on all lines designed for 20-t. loads. New bridges are designed to carry the loading of the standard trains with 20-t. axle loads increased by 10 %.

In *Egypt* and *Spain* the standard type train includes a locomotive with 22-t. axle loads.

The load of 22 t. per axle for some time at least ought to be the limit used in designing railway vehicles of all kinds : locomotives, railcars, carriages, and wagons.

b) Total weight of vehicles.

The railways concerned sent in the information summarised in Table 2, as regards the total weight in working order of the heaviest vehicles and its distribution.

This table which we have completed by incorporating the diagram of the standard train as defined by the Ministerial Circular of the 10th May 1927 for the French railways, calls for no particular comment.

c) Characteristics of the vehicles affecting their running over bridges and other structures.

The weight of each pair of wheels affects in particular the part of the superstructure on which it acts directly, i. e. the rails and sleepers carrying them.

The total weight of a vehicle, locomotive, or wagon is distributed over the whole of the substructure and consequently affects particularly the formation and even more the bridges and structures. The latter, therefore, according to their design and construction limit the running of very heavy loads much more than the track properly speaking.

The rules on which their calculation and design are based result from the running conditions laid down, usually in the form of a well defined standard train.

For this reason, considering the question solely from the point of view of the effect of the vehicles in motion on the bridges and structures, we asked the railways concerned to reply to the following question :

What are the modern vehicles which show the most unfavourable weight distribution as regards running over bridges and structures?

TABLE 3.

Characteristics of the vehicles with the most unfavourable weight distribution for running over bridges.

ADMINISTRATIONS.	Steam locomotives.			Electric locomotives.			High-capacity goods wagons.			Railcars.			Passenger carriages and other vehicles.			Miscellaneous. Railbuses, breakdown equipment.		
	P	$\frac{P}{A}$	$\frac{\Sigma P}{L}$	P	$\frac{P}{A}$	$\frac{\Sigma P}{L}$	P	$\frac{P}{A}$	$\frac{\Sigma P}{L}$	P	$\frac{P}{A}$	$\frac{\Sigma P}{L}$	P	$\frac{P}{A}$	$\frac{\Sigma P}{L}$	P	$\frac{P}{A}$	$\frac{\Sigma P}{L}$
	Metr. t.	Metr. t. per metre.		Metr. t.	Metr. t. per metre.		Metr. t.	Metr. t. per metre.		Metr. t.	Metr. t. per metre.		Metr. t.	Metr. t. per metre.		Metr. t.	Metr. t. per metre.	
Bulgarian State	17	10.6	9	...	..	...	15	...	3.08	10.5	...	...	13.5	...	2.51	...	...	...
Egyptian State	18.8 (2-6-4 tank locomotive)	9.5	6.72	...	...	...	13 (Tank wagon)	7.77	4.6	14.5 (*Sentinel* twin railcar)	6.8	1.95	12 (Steel carriage)	4.93	2.26	...	...	...
Northern of Spain (5′ 6″ gauge)	17.840 (Locomotive 4.600)	...	6.71	18.7 RP loco.) 16.5 (Locomotive 7.300)	...	... 6.08	17.11 (QQ bogie wagons)	< 8.5	5.13	13.5 ...	< 8.5 ...	< 6 ...	13.25 (AAthy steel carriage)	< 8.5	2.61	... ...	... ...	... ...
Madrid, Saragossa and Alicante (5′ 6″ gauge)	< 22	< 14.65	< 13.4	...	...	...	< 16	< 10.65	< 6.4	12.95	4.8	2.43	11.85	4.75	2.48	...	...	...
Western of Spain (5′ 6″ gauge)	16.972 (4-8-0 locomotive)	10.3	7.1	...	...	...	17 (4-wheeled wagon)	...	...	...	...	...	13 (8-wheeled carriage)	...	...	...	...	..
Alsace-Lorraine	20 (2-10-2 locomotive G. 16)	12.25	8.62	...	...	...	20	...	...	...	...	...	13	...	...	...	...	...
French Est :				...	...	...	⩽ 18	...	⩽ 7.2	< 16	...	< 7.2	< 16	...	< 7.2	...	...	...
On some lines	⩽ 21	...	⩽ 8															
Everywhere	⩽ 18.5	...	⩽ 8	...	...	...	⩽ 16	...	⩽ 5.4	< 16	...	< 5.4	< 16	...	< 5.4	...	...	...
	18.6 (2-10-2 locomotive 151.700)	12.4	7.6	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	16.8 (2-10-0 locomotive 150.000)	11.2	7.55	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
French State	19.8 (*Mountain* locomotive)	9.68	7.91	16.19 (Locotractor)	6	5.16	16 (Flat wagon)	8.9	2.7	12 (Aciéries du Nord railcar)	3.53	1.88	16 (Double-deck steel carriage)	6.4	2.74	...	...	...
	16.79 (*Decapod* locomotive)	11.2	7.67	...	...	...	15 (High-sided wagon)	8.35	4.9	...	...	...	...	...	...	...	..	...
French Nord	21.5 (2-8-2 locomotive 4.1200)	12.29	8.1	...	...	...	20.125 (40-t. well wagon)	11.18	4.08	...	...	...	...	...	...	...	..	...
	18.2 (2-10-2 locomotive 5.1200)	10.9	8.34	...	...	...	18.250 (90-t. flat ssy wagon)	14.9	7.4	16.965 (*Sentinel* railcar)	6.78	2 85	14.25 (Steel carriage)	5.7	2.76	21.725 (32-t. breakdown crane)	13.36	9.56
	19.2 (0-10-0 locomotives 5611/5670)	12.37	6.69	...	...	...	17.875 (50-t. flat slu wagon)	13.75	9.45	...	...	...	...	...	...	...	...	...

TABLE 3. *(Continued.)*

ADMINISTRATIONS.	Steam locomotives.			Electric locomotives.			High-capacity goods wagons.			Railcars.			Passenger carriages and other vehicles.			Miscellaneous Railbuses, breakdown equipment.		
	P	P / A	ΣP / L	P	P / A	ΣP / L	P	P / A	ΣP / L	P	P / A	ΣP / L	P	P / A	ΣP / L	P	P / A	ΣP / L
Paris-Lyon-Méditerranée	Metr. t. 18.9 (2-10-2 A locomotive)	Metr. t. per metre. 11.45	7.63	Metr. t. 19 (1 F 1 locomotive)	Metr. t. per metre. 8.81	6.18	Metr. t. ...	Metr. t. per metre. ...	...	Metr. t. 13.53 (Aciéries du Nord railcar)	Metr. t. per metre. 3.99	1.93	Metr. t. 14 (Streamlined carriage)	Metr. t. per metre 5.6	2.39	Metr. t ...	Metr. t per metre. ..	...
	19.9 (4-8-2 C locomotive)	11.7	7.51	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
P.O.-Midi (France)	19.1 (4-8-0 locomotive)	11.22	8 4	20 (4-8-4 locomotive)	11.3	7.94	17.08 (High-sided wagon)	9.5	5.57	19.062 (Electric railcar)	7.34	3.6	13.75 (Steel carriage)	5.5	2.37	14 (Alsthom railbus)	3.66	2.60
Algerian Rys.	18.5	...	...	20	...	...	16	8.9	...	...	...	...	10.25	...	...	...	...	...
Tunisian Rys. Standard gauge	15 (4-6-2 locomotive)	8.83	6.51	...	...	...	12 (Mineral wagon)	6.68	4.21	11.025 (Renault railcar)	4.41	1.52	9.812	3.92	2.02	...	..	...
Tunisian Rys. Metre gauge.	11.3 (*Mallet* locomotive)	9.43	5.72	...	...	...	11.375 (Mineral wagon)	7.5	4.68	...	...	...	7.637	4.02	1.78	...	...	...
Colonial Railways in French West Africa (Metre gauge)	9.925 (*Mallet* 2-6-0-6)	8.27	5.06	...	...	...	8.95	6.21	2.64	...	...	...	5.9	3.27	1.66	10.5 (25-t. breakdown crane)	7.25	3.3
Portuguese Rys. (1.665 m. = 5′ 6″ gauge)	16.8 (2-8-4 tank locomotive)	11.2	7.09	...	...	...	14.25	...	...	...	...	...	14.25	4.76	2.62	...	...	...
Mozambique Ry	16 (2-8-2 locomotive)	11.42	7 21	...	...	...	15.5	...	...	6.4	...	...	9.5	...	...	...	...	...
Rumanian State.	20	...	...	...	...	...	20	...	...	14.5	...	...	15	...	...	...	...	...
Czechoslovak State.	17.4 (4-6-2 locomotive)	8.5	6.52	16.9 (AA.AA locomotive)	7.05	5.45	15	7.5	2.94	14.5	5.8	2.7	13	5.2	2.28	..	...	...
	16 (4-8-2 locomotive)	8.3	6.67	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	14.3 (2-10-2 locomotive)	10.35	7.47	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Turkish State.	17.7	...	...	...	...	...	...	...	...	8	...	...	...	...	...	...	...	...
Jugoslav State	18.07 (2-10-0 locomotive)	11.28	8.03	...	...	...	13 (3-bogie wagon)	6.5	...	11 (3-bogie railcar)	5.25	3.45	11.166 (3-bogie carriage)	3.1	...	...	...	...

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Please give briefly their principal characteristics and any restrictions imposed on their working.

When dealing with the information received we thought it advisable to use the classification in five classes of line recommended by the International Railway Union, and the principles of which appear on leaflet R, No. 146 of the 1st January 1936.

This classification, based on the weight of the heaviest wagons allowed in full train loads over the different classes of line is defined in the following table :

Class of line.	Weight characteristics of the heaviest wagons allowed to run in full train loads over the different classes of line (4 or 8-wheeled — or 4-wheeled bogie wagons).									
	P		$\frac{P}{A}$		$\frac{P}{B}$		$\frac{2\ P}{C}$		$\frac{\Sigma P}{L}$	
	T./m.	T./ft.	T./m.	T./ft.	T./m.	T./ft.	T./m.	T./ft	T./m.	T./ft.
1st	15	4.5	9.4	2.82	12.4	3.72	12.4	3.72	3.6	1.08
2nd	16	4.8	10	3.0	13.3	3.99	13.3	3.99	5.4	1.62
3rd	16	4.8	10	3.0	13.3	3.99	13.3	3.99	6.4	1.92
4th	18	4.8	11.3	3.39	15	4.5	15	4.5	7.2	2.16
5th	20	6.0	12.5	3.75	16.6	4.98	16.6	4.98	8	2.4

In this table :

P = maximum axle load,

A = shortest wheelbase,

B = distance from the centre of an outer axle to the nearest buffer face,

C = distance between the centres of the two middle pairs of wheels,

= total length over buffers,

$\frac{\Sigma P}{L}$ = average load per linear metre.

We have classified, on the same principles, the various vehicles : locomotives, wagons, railcars, etc.

The main characteristics P, $\frac{P}{A}$ and $\frac{\Sigma P}{L}$ have been calculated for all types of vehicles reported by the Railways as being the most unfavourable for the bridges and structures.

The results are summarised in Table 3 which, although only included as a matter of information, gives an idea of the conditions under which any of the vehicles selected can be allowed to run over a given class of line.

This table shows that the worst vehicles as regards their effect on the bridges and structures are the following :

—	P	$\frac{A}{P}$	$\frac{\Sigma P}{L}$
	← T./m. (*Engl. t./foot*) →		
a) Steam locomotives :			
French NORD Mikado 4-1200 .	21.5 *(6.36)*	12.29 *(3.69)*	8.1 *(2.43)*
French EST 151-700	18.6 *(5.58)*	12.4 *(3.66)*	7.6 *(2.28)*
ALSACE-LORRAINE 151-G-16.	20 *(6.0)*	12.25 *(3.67)*	8.62 *(2.59)*
b) Electric locomotives :			
P.O.-MIDI 2D2	20 *(6.0)*	11.3 *(3.39)*	7.94 *(2.38)*
c) Goods wagons :			
French NORD 40-t. Ssy 41/43 well wagon	20.125 *(6.36)*	11.18 *(3.35)*	4.08 *(1.22)*
French NORD 90-t. Ssy 269-270 flat wagon	18.25 *(5.47)*	14.9 *(4.47)*	7.4 *(2.22)*
French NORD 50-t. Slw 76 flat wagon	17.875 *(5.36)*	13.75 *(4.12)*	9.45 *(2.83)*
d) Railcars :			
P.O.-MIDI electric	19.062 *(5.72)*	7.34 *(2.20)*	3.6 *(1.08)*
French NORD, Sentinel steam.	16.965 *(5.09)*	6.78 *(2.03)*	2.85 *(0.85)*
e) Passenger carriages :			
French State double-decker all-metal	16 *(4.8)*	6.4 *(1.92)*	2.74 *(0.82)*
f) Miscellaneous :			
French NORD 32-t. breakdown crane	21.725 *(6.4)*	13.36 *(4.0)*	9.56 *(2.87)*

These characteristics may be contrasted with those of the vehicles composing the standard trains :

—	P	$\frac{A}{P}$	$\frac{\Sigma P}{L}$
	← T./m. (*Engl. t./foot*) →		
1. *Locomotives :*			
Standard train (Regulations of the 24/10/25 in force in SPAIN)	22 *(6.6)*	14.66 *(4.4)*	10 *(3.0)*
Standard train (Ministerial circular of the 10/5/27 in force in FRANCE).	20 *(6.0)*	13.33 *(4.0)*	10 *(3.0)*
2. *Wagons :*			
France.	16 *(4.8)*	10.66 *(3.2)*	6.4 *(1.92)*
Spain	20 *(6.0)*	13.33 *(4.0)*	7.27 *(2.18)*

TABLE 3.

Characteristics of the vehicles with the most unfavourable weight distribution for running over bridges.

ADMINISTRATIONS.	Steam locomotives.			Electric locomotives.			High-capacity goods wagons.			Railcars.			Passenger carriages and other vehicles.			Miscellaneous. Railbuses, breakdown equipment.		
	P	$\frac{P}{A}$	$\frac{\Sigma P}{L}$	P	$\frac{P}{A}$	$\frac{\Sigma P}{L}$	P	$\frac{P}{A}$	$\frac{\Sigma P}{L}$	P	$\frac{P}{A}$	$\frac{\Sigma P}{L}$	P	$\frac{P}{A}$	$\frac{\Sigma P}{L}$	P	$\frac{P}{A}$	$\frac{\Sigma P}{L}$
	Metr. t.	Metr. t. per metre.		Metr. t.	Metr. t. per metre.		Metr. t.	Metr. t. per metre.		Metr. t.	Metr. t. per metre.		Metr. t.	Metr. t. per metre.		Metr. t.	Metr. t. per metre.	
Bulgarian State	17	10.6	9	...	..	...	15	...	3.08	10.5	...	...	13.5	...	2.51	—	—	—
Egyptian State	18.8 (2-6-4 tank locomotive)	9.5	6.72	...	...	...	13 (Tank wagon)	7.77	4.6	14.5 (*Sentinel* twin railcar)	6.8	1.95	12 (Steel carriage)	4.93	2.29	—	...	...
Northern of Spain (5′ 6″ gauge)	17.840 (Locomotive 4.600)	...	6.71	18.7 (RP loco.) 16.5 (Locomotive 7.300)	...	... 6.08	17.11 (QQ bogie wagons)	< 8.5	5.13	13.5 ...	< 8.5 ...	< 6 ...	13.25 (AAthv steel carriage)	< 8.5	2.64	— —	— —	— —
Madrid, Saragossa and Alicante (5′ 6″ gauge)	< 22	< 14.65	< 13.4	...	...	...	< 16	< 10.65	< 6.4	12.25	4.8	2.43	11.85	4.75	2.48	—	—	—
Western of Spain (5′ 6″ gauge)	16.972 (1-8-0 locomotive)	10.3	7.1	...	...	...	17 (4-wheeled wagon)	...	...	...	...	...	13 (8-wheeled carriage)	...	...	...	...	...
Alsace-Lorraine	20 (2-10-2 locomotive G. 16)	12.25	8.62	...	...	...	20	...	...	...	...	...	13	...	...	...	...	...
French Est :				...	...	...	< 18	...	< 7.2	< 16	...	< 7.2	< 16	...	< 7.2	..	—	...
On some lines	< 21	...	< 8															
Everywhere	< 18.5	...	< 8	...	...	...	< 16	...	< 5.4	< 16	...	< 5.4	< 16	...	< 5.4	...	...	...
	18.6 (2-10-2 locomotive 151.700)	12.4	7.6	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	16.8 (2-10-0 locomotive 150.000)	11.2	7.55	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
French State	19.8 (*Mountain* locomotive)	9.68	7.91	16.19 (Locotractor)	6	5.16	16 (Flat wagon)	8.9	2.7	12 (Aciéries du Nord railcar)	3.53	1.88	16 (Double deck steel carriage)	6.4	2.74	..	...	...
	16.79 (*Decapod* locomotive)	11.2	7.67	...	...	...	15 (High-sided wagon)	8.35	4.9	...	...	...	...	...	...	..	..	...
French Nord	21.5 (2-8-2 locomotive 4.1200)	12.29	8.1	...	...	...	20.125 (40-t. well wagon)	11.18	4.08	...	...	...	...	...	...	..	..	...
	18.2 (2-10-2 locomotive 5.1200)	10.9	8.34	...	...	...	18.250 (90-t. flat ssy wagon)	14.9	7.4	16.965 (*Sentinel* railcar)	6.78	2.85	14.25 (Steel carriage)	5.7	2.76	21.725 (24-t. breakdown	13.36	9.56
	19.2 (0-10-0 locomotives 5611/5670)	12.37	6.69	...	...	...	17.875 (50-t. flat slu wagon)	13.75	9.45	...	...	...	...	...	...	...	...	...

TABLE 3. *(Continued.)*

ADMINISTRATIONS.	Steam locomotives.			Electric locomotives.			High-capacity goods wagons.			Railcars.			Passenger carriages and other vehicles.			Miscellaneous Railbuses, breakdown equipment.		
	P	P / A	ΣP / L	P	P / A	ΣP / L	P	P / A	ΣP / L	P	P / A	ΣP / L	P	P / A	ΣP / L	P	P / A	ΣP / L
Paris-Lyon-Méditerranée	Metr. t. 18.9 (2-10-2 A locomotive)	Metr. t. per metre. 11.45	7.63	Metr. t. 19 (1 F 1 locomotive)	Metr. t. per metre. 8.81	6.18	...	...	...	Metr. t. 13.53 (Aciéries du Nord railcar)	Metr. t. per metre. 3.99	1.93	Metr. t. 14 (Streamlined carriage)	Metr. t. per metre. 5.6	2.32	...	...	...
	19.9 (4-8-2 C locomotive)	11.7	7.51	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
PO-Midi (France).	19.1 (4-8-0 locomotive)	11.22	8.4	20 (4-8-4 locomotive)	11.3	7.94	17.08 (High-sided wagon)	9.5	5.57	19.062 (Electric railcar)	7.34	3.6	13.75 (Steel carriage)	5.5	2.37	14 (Alsthom railbus)	3.66	2.09
[illegible]	18.5	...	...	20	...	...	16	8.9	...	...	...	...	10.25	...	...	...	...	...
Tunisian Rys. Standard gauge	15 (4-6-2 locomotive)	8.83	6.51	...	...	...	12 (Mineral wagon)	6.68	4.21	11.025 (Renault railcar)	4.41	1.52	9.812	3.92	2.02	...	...	...
Tunisian Rys. Metre gauge.	11.3 (*Mallet* locomotive)	9.43	5.72	...	...	...	11.375 (Mineral wagon)	7.5	4.68	...	...	...	7.637	4.02	1.78	...	...	...
Colonial Railways in French West Africa (Metre gauge)	9.925 (*Mallet* 2-6-0-6)	8.27	5.06	...	...	...	8.95	6.21	2.64	...	...	...	5.9	3.27	1.66	10.5 (25-t. breakdown crane)	7.25	3.3
Portuguese Rys. (1.665 m. = 5′ 6″ gauge).	16.8 (2-8-4 tank locomotive)	11.2	7.09	...	...	...	14.25	...	...	...	...	...	14.25	4.76	2.62	...	...	...
Mozambique Ry	16 (2-8-2 locomotive)	11.42	7.21	...	...	...	15.5	...	...	6.4	...	...	9.5	...	...	...	...	...
Rumanian State.	20	...	...	...	...	...	20	...	...	14.5	...	...	15	...	...	...	...	...
Czechoslovak State.	17.4 (4-6-2 locomotive)	8.5	6.52	16.9 (AA.AA locomotive)	7.05	5.45	15	7.5	2.94	14.5	5.8	2.7	13	5.2	2.28	...	...	...
	16 (4-8-2 locomotive)	8.3	6.67	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	14.3 (2-10-2 locomotive)	10.35	7.47	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Turkish State.	17.7	...	...	...	...	...	...	...	...	8	...	...	...	...	...	...	...	...
Jugoslav State	18.07 (2-10-0 locomotive)	11.28	8.03	...	...	...	13 (3-bogie wagon)	6.5	...	11 (3-bogie railcar)	5.25	3.45	11.166 (3-bogie carriage)	3.1	...	...	...	...

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The particulars of these different vehicles, and the table quoted above defining the characteristics of each class of line, show that the heaviest passenger vehicles, the French State double-decker carriages, can run without restriction except on the first-class of line.

The railways' regulations on the running of their locomotives are sometimes more restrictive than those of the above table of the International Railway Union; as a rule they limit the speed of the heaviest or newest locomotives according to their particular design or the line itself.

However, some railways, such as the *French Nord*, allow locomotives exceeding the limits for class 5 lines to work over their main lines without restriction.

d) Actual forces set up in the track by vehicles in motion.

This study of the static loads, i. e. of the weights per axle and the total weight of the vehicle ignores the loads transmitted to the axles by the driving gear and those resulting from the dynamic effect of the moving parts.

The corresponding reactions, especially at high speeds, and the hammerblow due to the moving parts can be appreciable, and equal to the static loads. They increase the loads on and the fatigue of the track in the same proportions.

Practically this field has not been fully explored up to now. We think that the builders should in future, by experiment and careful design, compensate or at least minimise, by balancing or by suitably distributing the loads and the dynamic forces, the effect of the constantly increasing weights and speeds of the vehicles. There is room for a complete investigation into this particular aspect of the question and the improved behaviour of both track and rails to be obtained.

Lateral thrust of the vehicles on the track.

e) The conditions governing the passage of vehicles over curves.

The passage of railway vehicles over curves has been fully investigated many times from the theoretical point of view.

The problem is to ascertain graphically or by calculation the exact position tyred wheels can take on the line after allowing for the play provided in the various parts during construction, the flexible parts such as the suspension springs and spring centering gear interposed between the wheels and axles and the rigid parts of the frame, and the various tolerances experience has shown to be necessary.

The increased loads as well as the higher speeds now ordinary practice with heavy trains have forced the builders to deal more seriously with the passage of vehicles over curves. The increase in the power of the locomotives required to work present traffic has resulted in the engines being much longer with a corresponding larger number of pairs of wheels.

There is more difficulty in making modern rolling stock negotiate curves.

The railways were asked therefore the following question :

What is the maximum rigid wheelbase of the various types of vehicles given in paragraph 1, which are the most unfavourable as regards negotiating curves?

What is the lateral play allowed per axle or group of axles?

Give details of the leading features of these vehicles and any restrictions as regards their use.

The particulars received are summarised in Table 4, on which the following remarks may be made :

The greatest rigid wheelbase, 9.80 m. (32′ 2″) is found on the *P.O.-Midi* light railcars known as the « Charentaises ». In spite of this wheelbase, these very

light vehicles — total weight 15.2 t. (14.9 Engl. tons), maximum speed 90 km. (56 miles) an hour — can take curves of 80 m. (4 chains) radius as a result of the lateral and longitudinal play in the axles, especially the end axles.

The *P.O.-Midi* 2D2 electric locomotives weighing 141 t. (138.8 Engl. tons) run regularly at 120 km. (75 miles) an hour and can also take curves of 80 m. (4 chains) radius, and curves of 150 m. (7 1/2 chains) radius at 50 km. (31 miles) an hour. The pivots of the end bogies and the two driving axles are given a total side play on each side of the centre of 163 mm. (6 7/16″) and 25 mm. (1″) respectively.

The former is the greatest amount of play reported by any of the railways consulted.

The steam locomotives now in service have not such a large amount of side play, and as a rule will not pass over curves of less than 120 m. (8 chains) radius. The side play of the coupled wheels and the bogies or trucks does not exceed 25 mm. (1″) and 150 mm. (6″) respectively. The engines are enabled to take small radius curves by thinning down the tyre flanges.

The effect of speed on the track.

f) High-speed train working.

We saw in an earlier paragraph that the study of the static loads carried by the rails was based on data to some extent theoretical and practically speaking incomplete because the dynamic effects of the parts in movement were ignored.

These effects have, however, not been ignored entirely in the design of many bridges and structures. By using approximations the additional effect known as impact, calculated from the relevant data and constants, can be brought into account by increasing the axle weights of the standard trains used in designing the different parts of the structure. But this is still a theoretical formula, as generally speaking the speed is not taken into account in the calculations. Obviously this impact cannot be independent of the speed as it disappears at very low speeds. The fatigue or deformation of the various parts of the structures under heavy loads at different speeds have been measured by recording instruments and have established that the impact varies as the speed. When the speed reaches the highest now run, parts of the bridge undergo impacts the magnitude of which is a high proportion of the static load imposed on the structure by the weight of the vehicle.

When very heavy trains or engines other than railcars or motor trains are run at speeds exceeding 120 km. (75 miles) an hour, the behaviour of the bridges and other structures must be carefully watched. It is very desirable that the investigations of certain Railways and of the Technical Committees of the International Railway Union in this connection should be continued and extended by the various Railways concerned.

In order to ascertain the exact maximum train speeds on the Railways, we asked them the following question :

What is as a rule, on your lines, the maximum speed of vehicles on which there is no restriction?

Have you any intention of raising the maximum speeds and for what classes of vehicle?

The information received is summarised in table 5.

On certain Railways, only relatively light vehicles and motor driven rakes of uniform composition are allowed to run at the present authorised maximum speed of 140 km. (87 miles) an hour. Railcars on the *Alsace-Lorraine*, *French State* and *P.L.M.* are run at this speed, and also rail motor trains of the *French Nord*. The *State* and *Nord* Railways expect to increase this speed to 150 km. (93 miles) an hour at some future date not yet fixed.

TABLE 4.

Vehicles with the most unfavourable characteristics as regards negotiating curves.

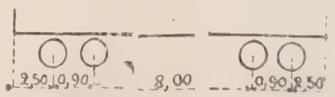
ADMINISTRATIONS.	Types of vehicles.	Rigid wheelbase (W.B.) (metres).	Lateral play (P) of axles or groups of axles *(Millimetres)*.	Other characteristics.	Restrictions on running.
Bulgarian State.	Steam locomotives	Max. W.B. = 4.80	...	...	...
	Goods wagons	Max. W.B. = 3.60	P = ± 35 (Goods wagons and passenger carriages).	...	Minimum radius R of curve taken = 180 m.
Egyptian State	4-4-2 locomotives Nos. 6 to 25	W.B. = 5.283	P leading bogie axles = ± 1.2. P coupled wheels = ± 2. P trailing carrying axle = ± 7.2.	...	*Rule :* Every vehicle should be able to negotiate R = 120 m. and run at speed through R = 600 m.
Northern of Spain (5′ 6″ gauge).	Locomotives 4 300	Max. W.B. = 5.70	P varies from 3 to 19 mm.	...	
	Afhv carriages	Max. W.B. = 8.37	When the W.B. varies from 3.2 m. to 8.37 m.		
Madrid, Saragossa and Alicante (5′ 6″ gauge).	Locomotives 1 700	W.B. = 5.55	P I II III = 1. P IV = 15.	...	...
	Rrf wagons 535-559	...	P = 5.		
	W.E. railcars 401-404	...	P = 51.		
	AAwffw carriages 58-77	...	P = 53.5.		
Western of Spain (5′ 6″ gauge).	4-8-0 locomotives	W.B. = 5.70	P I II III = 2. P IV = 16.	...	The smallest curve is 300 m. radius.
	4-wheeled wagons	...	P = 10.		
	8-wheeled wagons	...	P = 2.		
	8-wheeled carriages	...	P = 2.		
Alsace-Lorraine	4-8-4 T. 20 locomotives	W.B. = 5.91	P leading bogie axles = 96. P trailing bogie axles = 96. P I II III IV = 1.5.	Flanges of 2nd and 3rd pairs of wheels thinned down 10.5 mm.	According to the regulations all locomotives have to pass over curves of R = 180 m. In practice they can run over curves of R = 80 m. and 140 m. according to type.
	4-wheeled wagons	W.B. = 4.20	...	...	Minimum radius of curve taken = 150 m.
French Est.	Locomotives	...	No lateral play except on bogies and trucks when P max. = ± 150. Lateral play given so as to meet the rule (*).	...	(*) *Rule :* Every vehicle must pass in ordinary running curves of R = 150 m. and yard curves of R = 80 m.
	Other vehicles	Max. W.B. = 9.00			
French State	*Decapod* locomotive.	W.B. = 6.20	P = 24.	Can run on curves of	R = 172 m. 140 118 103 90 83.
	Mountain locomotive.	W.B. = 6.15	P = 24.		R = 172 m. 144 124 109 103 100.
					with a gauge of 1.44 m. 1.445 1.45 1.455 1.46 1.465.
French Nord	Locomotives	W.B. = 7.62	P trailing axle = ± 20.	...	Can run over curves of R = 145 with a gauge of 1.445.
	Locomotives	W.B. = 6.20	P trailing axle = ± 25.	...	Can run over curves of R = 90 with a gauge of 1.445.
	Wagons	W.B. = 7.20	P = ± 15.	...	Can run over curves of R = 75 with a gauge of 1.465.
	Carriages	W.B. = 8.50	P = ± 15.	...	Can run over curves of R = 100 with a gauge of 1.465.
P.O.-Midi (France).	4-6-2 steam locomotives 801/806 and 821/829	W.B. = 4.10	P leading bogie centre pin = ± 45. P back axle = 46.5. P I II III = ± 2.	Flanges of 2nd pair of wheels thinned down.	Can run over curves of R minimum = 142 m. Can run at the maximum speed on the main lines of the system.
	Electric locomotives 2-D-2	W.B. = 6.06	P bogie centres leading and trailing = ± 163. P I II III = ± 25.	...	Can take curves of R = 80 m. Can run at 50 km./h. over curves of R = 150 m Allowed to run at the maximum speed over the electrified lines of the Railway .
	KKuw wagon	W.B. = 4.50	P = ± 10 } + lateral play of bogie bolster = 15 mm.	...	...
	TTyf wagon	Bogie W.B. = 1.80	P = ± 25 }	...	...
				Max. speed : 90 km./h.	
	« Charentaise » railcars ZZEt 23 601/608	W.B. = 9.80	Lateral P = ±12 ±1 ±1 ±12 Longitudinal P = ± 2 ±1 ±1 ± 2	The two centre axles are driving	No restriction.

TABLE 4. *(Continued.)*

ADMINISTRATIONS.	Types of vehicles.	Rigid wheelbase (W.B.) (metres).	Lateral play (P) of axles or groups of axles *(Millimetres).*	Other characteristics.	Restrictions on running.
Algerian Rys.	...	Max. W.B. = 8.40	P = 35 on center axle of 6-wheeled carriage.	...	Run over curves of R = 150 m.
Tunisian Rys. — Standard gauge	2-10-0 locomotives 221	W.B. = 6.075	P = 1. P 5th axle = 17.5.	The coupling rod crank pins are spherical.	
	6-wheeled	W.B. = 8.20	Lateral P end axles = 10. Middle axle = 62.		
	$AB^2 C^4$ carriages	...	Longitudinal P = 8. End axles = 36. Middle axle = 8.	... ...	
Metre gauge.	2-10-0 locomotives 851	W.B. = 5.50	P = 0.5. P 2nd axle = 20. P 5th axle = 35.	Flanges on 3rd pair of wheels thinned down. Sliding coupling rod crank pins.	No speed restrictions other than those due to the condition of the track.
	4-wheeled carriages	W.B. = 4.50	P = 32.		
Colonial Railways in French West Africa (Metre gauge).	2-8-2 locomotives Class 40 000	W. B. = 5.45	P I II III IV = 1. P trailing carrying axle = 15.	...	No special restriction.
	Bogie carriages	Bogie W.B. = 1.80	P = 6.	...	
Portuguese Rys. (5' 6" gauge).	2-8-2 locomotives	W.B. = 5.25	P I IV = 24.	...	No special restriction.
Mosambique Rys.	...	Max. W.B. = 5.284	...	...	...
Rumanian State.	Steam locomotives	Max. W.B. = 6.00	P = 0.5.	...	...
	Railcars	W.B. = 8.00	...	...	
Czechoslovak State.	2-10-2 steam locomotive 524	W.B. = 5.52	P carrying front axle = ± 65. P carrying back axle = ± 75. P II V = ± 22.	Flanges of 3rd pair of wheels thinned down 10 mm.	Run without difficulty over curves R = 180 m.
	Electric locomotives	Bogie W.B. = 2.40	...	...	Run without difficulty over curves R = 120 m.
	4-wheeled wagons	W.B. = 4.50	P = ± 1.	...	Run without difficulty over curves R = 150 m.
	4-wheeled railcars	W.B. = 4.50	Lateral P = ± 1. Longitudinal P = ± 1.	...	Run without difficulty over curves R = 150 m.
	Bogie railcars	Bogie W.B. = 3.60	Lateral P = ± 1. Longitudinal P = ± 1.	...	Run without difficulty over curves R = 120 m.
	4-wheeled carriages Class B.C.e.	W.B. = 9.40	Lateral P = ± 4. Longitudinal P = ± 10.	...	Pass curves of R < 150 m.
	Bogie carriages	W.B. = 2.50	Lateral and longitudinal, bogies, P = ± 1.	...	
Turkish State.	2-10-2 locomotives	W.B. = 4.50	...	...	...
	4-wheeled wagons	W.B. = 4.50			
	Railcars	W.B. = 7.00			
	Carriages	W.B. = 9.00			
Yugoslav State	All vehicles	W.B. Max. = 4.50 W.B. > 4.50	P = 0. P given by P = 2.8 a.c. With P outer axles ⩾ 15. and P centre axles ⩽ 60.	...	...

Note : The roman numerals I, II, III... refer to the coupled pairs of wheels of the locomotives.

TABLE 5.

Maximum speeds being run, and under consideration.

(T = Trains. S = Steam. E = Electric. Rc = Railcars F. M. T. = Fast motor trains.)

ADMINISTRATIONS.	Maximum speed allowed (km./h.)	Maximum speed under consideration (km./h.)	Remarks.
...rian State.	T 75	T 75	...
...pian State	T 90	T 90	...
...thern of Spain . . . . . 5′ 6″ gauge).	S.T.-E.T. 100 Rc. 120	S.T.-E.T. and Rc. } > 120	...
...id, Saragossa and Alicante 5′ 6″ gauge).	100	100	...
...ern of Spain . . . . . 5′ 6″ gauge).	S.T. 85	S.T. 85	...
...e Lorraine	S.T. 120 Rc. 140	S.T. 120 Rc. 140	... ...
...h Est.	120	125 (1)	(1) On the Paris-Strasbourg and Paris-Mulhouse lines.
...h State	S.T.-E.T. 120 Rc. 140	S.T. 130 (2) Rc. 150 (2) E.T. 150 (3)	(2) Paris-Havre line. (3) Paris-Le Mans line.
...h Nord	S.T. 120 F.M.T. 140	S.T. 140 (4) F.M.T. 150	(4) On lines equipped with automatic block signalling. ...
...-Lyon-Méditerranée . . . P.L.M.)	S.T. 120 Rc. 140	S.T. 120 Rc. 140	...
...-Midi (France).	S.T. 120 E.T. 130 (5)	S.T. 120 E.T. 140	(5) This speed is authorised on the Orléans-Tours section for trains hauled by 2D2 locomotives hauling steel carriages.
...erian Rys.	T. and Rc. 120	T. and Rc. 120	...
...sian Rys. } Standard gauge } Metre gauge. .	T 75 T 70	Rc. 100 Rc. 90	... ...
...ial Railways in French West Africa . . . . . Metre gauge).	T 60	Rc. 80	...
...guese Rys. . . . . . 1.065 m. = 5′ 6″ gauge).	T 120	T 120	...
...mbique Rys. . . . . . Lourenço-Marques).	T 80	T 80	...
...anian State.	T 110	T 120	...
...hoslovak State.	T 110	T 120 Rc. 130	... ...
...kish State.	T 75	T 95	...
...oslav State	T 100	T 120	.

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The *P. O.-Midi* Railways are authorised to operate ordinary trains of steel vehicles, hauled by 2-D-2 electric locomotives, at 130 km. (80.8 miles) an hour between Orléans and Tours.

The *French State* Railways expect to exceed this speed between Paris and Le Mans when this section has been electrified.

Trains hauled by steam locomotives are limited to a maximum speed of 120 km. (75 miles). Three Systems — *French Est, State* and *Nord* — are considering an increase of this figure to 125, 130 and 140 km. (77.7, 80.8 and 87 miles) an hour respectively.

Ten railways out of eighteen are considering an increase in the actual maximum train speeds.

Apart from the data used in designing bridges and other structures mentioned above, there is no practical way of ascertaining beforehand if a track of any given construction is or is not able to carry the traffic at higher speeds or to stand heavy loads at previously fixed high speeds.

In fact, all that is possible practically speaking is to calculate beforehand the strength of a given track under static loadings.

The dynamic stresses the track has to withstand are not yet well enough known to bring them into account in appropriate calculations.

Under these conditions, every endeavour should be made to draw, from experiments and tests over sufficiently long sections and during a long enough period for all the phenomena and effects to be examined, such conclusions as will allow of drawing up practical rules in this respect.

This is the much more necessary that it is not always possible to know beforehand how old or new vehicles will behave at the ever increasing speeds to which they are submitted.

Thus, locomotives, railcars or wagons known to be perfectly steady at certain speeds, develop for reasons still unexplained and often only cured by empirical methods, movements known as « hunting », « nosing », etc., when a maximum speed peculiar to each is exceeded.

The guiding of the locomotives and other vehicles, the side thrust of the axles and wheel flanges in running, the wear of tyres and flanges, and parts in motion, the centering gear, couplings, etc... all have an unavoidable though not always well known influence on the behaviour of vehicles at high speeds.

This again is an almost unexplored field which could be studied with advantage in combining the data to apply to suitable experiments and measurements with those obtainable from the theoretical considerations on the general balancing of the vehicles and the particular movements they can be submitted to during running.

In our opinion, therefore, the best way to appreciate how far the railways can profit by the permission to operate vehicles with 22-t. axle loads at speeds approaching 150 km. (93 miles) an hour over the track in its present condition and how far the track has to be strengthened or altered, is to carry out methodically a series of tests of this sort.

* * *

CHAPTER II.

Present-day main-line permanent way.

Rails.

a) Rail manufacture and inspection.

As we have already seen, the increase in axle loads and speeds has subjected the rails to greater static loads to which must be added the dynamical effects which increase rapidly with the speed.

The metal in the rails from the moment they are laid in the track is in consequence subjected to a continuous series of severe strains.

The traffic conditions have been modified so considerably that the strength and quality of rails used on main lines should be increased proportionately if the number of broken or defective rails is not to attain a dangerous figure.

When Question II « Resistance of rails to breakage and to wear » was considered at the 1930 Madrid Congress, certain conclusions and general recommendations were made and were adopted subsequently by most of the Railways.

It seemed to us opportune to ascertain the steps actually taken and the results obtained in the manufacture and inspection of standard rails and also as regards new investigations and experiments undertaken by the railways consulted.

Rail manufacture.

The first question we asked in this respect was :

What process is used in making the steel for new rails to be laid on main lines? Give details of the kind and general composition of the metal.

The replies received have been summarised in Table 6.

The THOMAS, SIEMENS-MARTIN and BESSEMER processes are all three used for making rail steel, the only restriction in their use being by the Portuguese Railways which do not accept the Thomas process for steel of 80 kgr./mm² (50.8 Engl. tons/sq. in.) quality. Some works are now supplying rails of steel made in electric furnaces.

As regards blooming and rolling the bars, a minimum cross section area of the ingots and the lowest possible final rolling temperature are specified by most railways. The *Madrid-Saragossa-Alicante* and the *Western of Spain* Railways consider this temperature should not exceed 850° C. (1 530° F.).

Most of the Railways specify sufficient discard to remove all traces of piping and segregation and tests pieces are taken from the discards.

The *French* and *Portuguese* Railways in addition insist on the top discard being at least 12 to 18 % of the ingot weight.

From the replies received, it appears that the rail steel should have an average tensile strength of 70 kgr./mm²(44.4 Engl tons/sq. in.) and an elongation of 10 %. These values vary however considerably from one railway to another: the tensile strength from 65 to 88 kgr./mm² (41.3 to 55.9 Engl. tons/s. in.) and the elongation from 15 to 7 %. The coefficient of quality R + 2A (tensile strength in kgr./mm² + 2 × elongation %) specified by most railways varies between 92 and 100. The harder rails are used as a rule where wear is most serious, such as on small radius curves and in points and crossings.

As regards chemical composition, the *Bulgarian* and *Jugoslav State* Railways accept relatively soft rails with only 0.3 to 0.35 % of carbon, whereas on the other railways the carbon content varies between 0.4 % for 65 kgr./mm² (41.3 Engl. tons/sq. in.) rails to 0.55 % for 80 (50.8 tons/sq. in.).

The average content of other elements is : manganese 1 %; silicon 0.1 to 0.2 %, phosphorus usually below 0.07 %, and sulphur below 0.04 %.

The recommendations agreed at the Madrid Congress have been followed on the whole, especially as regards increasing the amount the steel is de-oxygenated or killed.

As regards straighthening the rails some of the makers camber the rail whilst hot, so that in cooling they become practically straight.

Inspection of rails.

The replies to the question on inspection have been brought together and summarised in Table 7 which shows the tests made to eliminate defective rails and those made experimentally or for information.

TABLE 6. — Rail manufacture.

(t = final rolling temperature; p = weight of top discard; P = total weight of the ingot; R = breaking load; E = Elongation).

ADMINISTRATIONS.	Manufacturing process of the metal.	Precautions required by the Specifications.		Mechanical requirements of the specifications.			Chemical composition, %.					Manufacturing tolerances allowed by the specification.			Miscellaneous; period of guarantee.
		Refining and rolling.	Discard.	Breaking load, kgr. per mm².	Elongation %	Other requirements.	C	Mn	Si	P	S	Length in mm.	Sectional dimensions in mm.	Weight %.	
Bulgarian State.	*Siemens-Martin*, Bessemer, Thomas (basic) or any other.	Cross section of ingot ⩾ 20 times that of the rail as rolled. $\frac{\text{—}}{t}$ as low as possible.	Sufficient to remove all traces of segregation, piping or blow holes.	⩾ 70	...	R × A ⩾ 900 (R = Tensile strength, A = Elongation).	Contents specified.					± 2	Foot : ± 1; total height and width of the head : ± 0.5; thickness of the web : + 0.5-0.25.	— 2 %; excess over 1 % not paid for.	Guarantee : 5 years.
							⩾ 0.3	...	...	⩽ 0.08	⩽ 0.05				
Egyptian State	Siemens-Martin or Bessemer.	The largest cross section of the ingot should be ⩾ 0.129 m².	Sufficient to remove completely all unsound metal.	Not specified.			Contents as laid down in the specification. *a)* with Siemens-Martin acid process : 0.45/0.55 | 0.75/0.9 | 0.1/0.3 | ⩽ 0.06 | ⩽ 0.06 *b)* with Siemens-Martin basic process : 0.5/0.6 | 0.75/0.9 | 0.1/0.3 | ⩽ 0.05 | ⩽ 0.06 *c)* with Bessemer acid process : 0.4/0.5 | 0.75/0.95 | 0.1/0.3 | ⩽ 0.07 | ⩽ 0.06					± 4.8	Foot : ± 1. Other dimensions : ± 0.5.	+ 1 % — 0.5 %	Guarantee : 6 years.
Northern of Spain	...	...	...	> 72	⩾ 10 %	...	0.5/0.6	0.8/1.20	0.15/0.25	< 0.05	< 0.06	...	...	...	...
Madrid, Saragossa and Alicante and Western of Spain	*Bessemer* or other.	Section of ingot ⩾ 0.15 m². t = ⩽ 850° C.	...	> 72	⩾ 10 %	R + 2 A ⩾ 95	Contents laid down in the specification : 0.45/0.55	0.8/1.10	0.15/0.20	< 0.07	< 0.08	± 3 at 20°	On all dimensions : ± 0.5.	± 2 %; excess not paid for.	Require a fine grain, compact and homogeneous structure. Guarantee : 6 years.
French main-line Rys. Algerian and Tunisian Rys.	*Thomas* (in France).	Section of the ingot ⩾ 20 times that of the rail.	Head : to give a bar of 0.70 m. meeting the drop test : $p \geqslant \frac{12\ P}{100}$	3 qualities :			Average chemical composition (not specified) :					± 2 for length ⩽ 18 m.	Foot : ± 1;	± 2 %; excess over 1 % not paid for.	Guarantee : 10 years, but the balance held against the guarantee is paid in 6 years.
	Martin { 44-kgr. bull-headed rails, used on the Midi.			⩾ 65	⩾ 10	R + 2 A ⩾ 92	0.45	0.95	0.125	0.07	0.04				
				⩾ 70	⩾ 9	R + 2 A ⩾ 94	0.47	1.05	0.1	0.065	0.035		Other dimensions : ± 0.5.		
	Bessemer (Tunis) or any other.	t as low as possible.	Bottom : to give a bar of 0.30 m. meeting the tensile test.	⩾ 80	⩾ 7	R + 2 A ⩾ 98	0.51	1.15	0.1	0.065	0.035	± 3 for 18 m. < L ⩽ 24			Quality 70 is the only one used in Tunis.
Portuguese Rys.	Thomas, Bessemer, Martin or any other — *except Thomas for 80 kgr. quality.*	Section of ingot ⩾ 20 times that of the rail.	Head : a bar of 1.30 m. meeting the drop test $p \geqslant \frac{18\ P}{100}$	2 qualities :											
				Q.68 : 68/76	⩾ 12	R + 2 A ⩾ 96	...	...	...	...	...	± 2 for L < 12 m.	Foot : ± 1; Other dimensions : ± 0.5.	± 2 %; excess over 1 % not paid for.	Guarantee : 6 years.
			Bottom : bar of 0.35 m. meeting the tensile test.	Q.80 : 80/88	⩾ 8	R + 2 A ⩾ 100	...	...	...	...	...	± 3 for 12 ⩽ L ⩽ 18 m.			
Rumanian State.	Thomas, Bessemer, Martin or any other.	Volume of the ingot ⩾ that of 3 rails 12 m. long.	As the French main-line railways.	⩾ 72	10 to 15	Elastic limit E ⩾ 38 R + 2 A ⩾ 96	Usual contents 0.45/0.55 | 0.80/1.20		Specified content > 0.12	Usual contents about 0.07	about 0.04	± 2 for L < 15 m. ± 3 for 15 ⩽ L ⩽ 24 m.	As on the French main-line railways.		As on the French main-line railways.
Czechoslovak State.	*Siemens-Martin* or Thomas.	...	...	2 qualities : ⩾ 65 ⩾ 75	... for small-radius curves	...	Usual content 0.40/0.50	Content as specified 0.80/1.40	Usual contents 0.10/0.20	0.04/0.07	0.03/0.05	...	...	...	...
Turkish State.	...	...	...	⩾ 70	⩾ 10	R + 2 A ⩾ 94	...	...	...	...	...	...	...	...	...
Yugoslav State	Siemens-Martin or Thomas.	...	...	⩾ 70	⩾ 10	R + 2 A ⩾ 92	Contents as laid down in the specification. ⩾ 0.35	0.80/1.40	0.10/0.28	P + S ⩽ 0.10		...	...	...	...

TABLE 7.

Acceptance tests of rails.

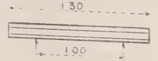
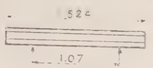
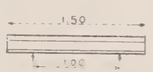
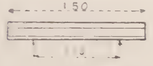
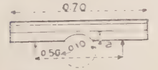
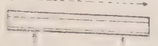
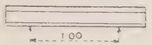
ADMINISTRATIONS.	Drop tests.	Hardness tests.	Tensile test.	Other mechanical tests.	Macrographical or micrographical tests.	Chemical analysis.
Bulgarian State.	 A short length from the top of an ingot from each cast. First blow (Kg./M.) = 3 000 × $\frac{m}{1\,000}$ m moment of inertia of the rail in cm⁴. Subsequent blows = 1 200 × $\frac{m}{1\,000}$, continued until the deflection f = 100 mm. The length of rail shall not break nor crack. One test out of 3 shall be continued to fracture for examination of the structure.	Diameter of the ball = 19 mm. Pressure gradually increased for 15 secs. up to 50 t., maintained for 15 secs. Depth of impression ≤ 5 mm. One test per batch of 100 rails.	Test piece cut out of the bottom discard; diameter = 20 mm.; length = 220 mm. R ≥ 70 R × A ≥ 900 One test per cast. (R = Tensile strength A = Elongation, E = Elastic limit.)	..	A macrograph is taken from the top of one ingot per cast for information. If unsatisfactory, additional mechanical tests can be required.	A complete analysis per cast, confirming more especially the specified composition.
Egyptian State (Tests for 47-kgr. rails).	 2 lengths from the head per cast. Tup of 1 016 kgr. Height of drop H = 7.62 m. The length must not break nor take a permanent set of more than 80 mm. If desired, the length is notched and broken for examination. Check tests are made from the foot of the rails from the head of the ingot.	A Brinell hardness test is made on the top of a drop test length.	One test for information only, per 50 tons from the foot of a drop test length, diameter 14 mm. Length between gauge marks = 50 mm.	Optional tests : Lateral shock tests on the rail head. The test pieces are 25.4 mm., cut out of the rail, and must not break under a blow of 9.39 Kg.-M. given by a pendulum.	Macrographic tests optional.	A complete analysis per cast to the specified contents.
Northern of Spain	 1 000-kgr. tup. Heigth of drop H = 5 m.	10 mm. ball; 3000-kgr. load. Brinell No. ≥ 207.	R > 72 A > 10 %	Static bend test on a 1.5-m. length with supports 1 m. apart. f = 0 for a load of 30 t. f = 0.025 for a load of 60 t. One test per 200 rails.	No tests of this kind made.	Chemical analyses are taken.
Madrid, Saragossa and Alicante, and Western of Spain	 300-kgr. tup. For 45-kgr. rails and a drop H = 3 m., the elastic deflection f must ≤ 0.01. For 45-kgr. rails and a drop H = 6 m., the maximum deflection f = 0.03.	As on the Northern of Spain.	Cylindrical test piece, diameter : 15 mm. test length 100 mm. Cut from the top of the rail head. R ≥ 72 A ≥ 10 % R + 2 A ≥ 95	1.5-m. lengths — supports 1 m. apart. For 45-kgr. rails { f = 0 for a load of 32 900 kgr.; f = 0.025 for a load of 72 000 kgr. No fracture at a load of 78 000 kgr. One static bend test per 200 rails.	Micrographic test optional for information.	A partial analysis per cast to get the carbon content. A complete analysis per 10 casts to confirm the specified composition.
French, Algerian and Tunisian Rys.	 A length from the head of each ingot. Notch a = $\frac{2}{5}$ of depth of rail head. 300-kgr. tup. H = weight of rail per metre × constant C. C 0.10 for 65 quality. 0.095 for 70 quality. 0.090 for 80 quality. } Without break nor longitudinal crack. Check tests to be made on the foot of such rails from ingot head.	(For information only.) By standard test. 10 mm. ball; 3 000-kgr. load; at most 3 tests per cast.	Test piece cut from 0.3 m. length from bottom of ingot at 2/5th from the top of the rail head. Standard test. Diameter : 13.8 mm.; length 120 mm. R ≥ 65 A ≥ 10 R + 2 A ≥ 92 R ≥ 70 A ≥ 9 R + 2 A ≥ 94 R ≥ 80 A ≥ 7 R + 2 A ≥ 98 One test per three casts. — Check tests on preceding and following cast.	Optional tests for information only : 1. Charpy resilience test on small test pieces; 2. Drop test with the rail foot in tension.	One macrograph per cast from the top of an ingot and one from the bottom must show no trace of piping nor clearly visible segregation nor inclusions. Check tests optional.	A partial analysis per cast to give the C, Mn and P contents. A complete analysis per 100 tons, for information.

TABLE 7. *(Continued.)*

ADMINISTRATIONS.	Drop tests.	Hardness tests.	Tensile test.	Other mechanical tests.	Macrographical or micrographical tests.	Chemical analysis.
Portuguese Rys.	 One length per ingot. For 45-kgr. rails Initial blow : 6.000 Kg.-M. Subsequent blows : 3.500 Kg.-M. continued until $f \geqslant 90$ mm. for 68 quality. $f \geqslant 80$ mm. for 80 quality. } without breaking or cracking. With one cast out of five the test continued until fracture after notching the foot. Check tests made on head of rails from ingot head.	(For information only.)	Test piece cut in the bottom discard; diameter 20 mm.; test length 145 mm. $68 \leqslant R \leqslant 76$ A 12 $R + 2A \geqslant 96$ $80 \leqslant R \leqslant 88$ $A \geqslant 8$ $R + 2A \geqslant 100$ One test per cast of 50 t. or more; one test per 3 casts of less than 50 t. Check tests.	...	Two macrographs per cast from top discards to show no clearly marked piping or segregation.	An analysis per cast giving C, Mn, P and sometimes Si and S.
Rumanian State.	Like the French main-line Railways, for quality 65 constant C = 0.1. One test per ingot. Check test on the foot of rails from the head of the ingot.	No.	Test piece cut from bottom discard; diameter 25 mm.; test length 200 mm. $R \geqslant 72$ $10 \leqslant A \leqslant 15$ $E \geqslant 38$ One test per cast.	...	The inspector can require a macrograph in case of doubt.	An analysis per cast giving C, Mn, P, and confirming the Si content imposed.
Czechoslovak State.	One test per cast, as a rejection test.	(For information only.)	One test per cast : rejection test. $R \geqslant 65$ } for rails laid on sharp curves. $R \geqslant 75$ }	Static bend test for information only.	Macrographic and micrographic tests for information only.	Analyses to confirm the specified Mn content.
Jugoslav State	 Initial blow (Kg.-M.) $= \frac{J}{e^2}$. J = Moment of inertia of the rail relatively to the centre of gravity. e = Distance between the centre of gravity and the most highly stressed fibre. Subsequent blows $= 0.4 \frac{J}{e^2}$ up to $f = \frac{60}{e}$.	As on the Bulgarian State; the depth of the impression should be between 3.5 mm. and 5.5 mm.	$R \geqslant 70$ $A \geqslant 10$ $R + 2A \geqslant 92$	Static bend tests are made especially from the rail foot in the transverse direction. With supports 100 mm. apart the deflection should be as much as 4 mm.	...	Analysis to confirm the specified contents.
Notes.	The drop test is a rejection test on all railways mentioned.	The hardness test is not a rejection test on the Spanish railways.	With the exception of the Egyptian State railways, the tensile test is a rejection test on all railways mentioned.	The static bend test is a rejection test on the Spanish Railways.	Macrographic tests are rejection tests on the French and Portuguese Railways.	...

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The usual methods in use to ensure good-quality rail steel include :

— chemical analysis, required by all the railways replying;

— making sure the metal is homogeneous, either by an examination of a broken section or by a macrographical examination often made as a matter of information, but which on the *French main-line* Railways and *Portuguese Railways* is a rejection test; this test if need be can be completed by a micrographical examination;

— eliminatory tensile tests are required by all the railways except the *Egyptian State,* which require tensile test pieces cut from the rail to be submitted, so as to ascertain the breaking strength, the elongation, and if desired the elastic limit;

— resilience tests which consist either in measuring as a matter of information the resilience of the metal on small test pieces cut from the body of the rail or more often of subjecting several short lengths of rail to eliminatory shock tests to which they have to stand up under specified conditions. Experiments are made during such tests to measure the actual value of the kinetic energy of the blow which caused fracture so as to deduce therefrom the resilience of the full rail section;

— hardness tests, usually for information only, to complete and check the tensile test and to give an idea of the resistance of the rails to wear;

— static deflection tests and sometimes lateral shock tests on the rail head, which are only resorted to on a few railways.

Nonetheless, the manufacture of a rail steel of the quality best suited to resist wear to stand the increasing strain due to the new operating methods could well be improved with advantage.

The railways now having to face constantly increasing loads and speeds are much concerned and put to much expense in keeping the track in good order and want rails fully able to stand the greater stresses set up.

Some of the railways have considered whether their anxieties could not be met by heat-treating the present rails and by using special rail steels.

Heat treatment of rails.

The heat treatments used modify the structure of the metal by heating the rail and then hardening it in order to improve its resistance to wear, without making it more brittle.

A number of processes have been devised.

The Sandberg process is one of them : by cooling the bars progressively under control, the structure is definitely improved.

The process of the Neuves-Maisons Works and that of the Providence Works, consisting in quenching the rail head in water, are more recent processes. The latter differs from the former in that the rail is kept moving through a water tank with its head partially immersed, after a preliminary heat in a furnace to equalise its temperature. After hardening it passes through a second furnace in which it is suitably tempered at a definite temperature. These processes, like that of the Maximilianshutte tend to give the rail head a sorbitic or martensitic structure.

The *Northern of Spain* and the *Turkish State* Railways have carried out a few experiments in this direction.

The *French main-line* Railways are largely using heat-treated rails.

All flat-bottomed rails ordered by the *French Est* and all those ordered since 1932 by the *P.O.-Midi* are heat-treated, either by the Neuves-Maisons or the Providence method.

The *French State* uses rails treated by these processes on its main-lines or where there is much braking or slipping, on less important sections.

The *Paris-Lyon-Méditerranée (P.L.M.)* and *Nord* Railways are generally using heat-treated — sorbitic or martensitic — rails at places where the rails are stressed most severely, i. e. in the sections with the heaviest and most dense traffic, when there is much braking and slipping, or on sharp curves.

The *Alsace-Lorraine* Railways use in points and crossings rails treated by the SANDBERG and NEUVES-MAISONS processes.

Heat-treated rails have to pass more severe drop, tensile, resilience, and hardness tests.

Owing to the long time the behaviour of the rail in service has to be followed, especially the behaviour of the metal during the slow or successive changes it can undergo in the track, no opinion can be given as to the practical advantage of the heat-treatment in lengthening the life of the rails.

There appears to be no doubt that the metal in the rail head does not crush down so easily. The observations recorded, however, seem to show that these processes, especially quenching part of the rail head in water, can only be applied to carefully manufactured steel of very satisfactory quality and homogeneity. If generally used, the effect would be to raise the quality of rail steel.

Use of special steels. — We asked the railways if they use, on their running lines, rails of special steel or composite rails part of which is special steel.

The replies show that many railways use manganese steel or chrome-nickel steel in points and crossings.

The *French State* on running lines laid a year ago 30 chrome-copper steel 55-kgr. (34.9 tons/sq. in.) rails in a heavily used section near Paris. The *Nord* recently laid some 50 nickel-chrome steel rails in places subjected to slipping and frequent braking. No practical conclusions can be drawn at present from these two tests. The *Nord* intends to try in the near future a few hard chrome-copper (70 to 80-kgr. = 44.4 to 50.8 tons/sq. in.) rails and 14 % manganese steel rails.

The usual practice of the *Jugoslav State* Railways is to have the outer rail on sharp curves and on steep gradients on certain lines made of special steels containing either 0.2 % molybdenum or 1.8 % manganese with a minimum tensile strength of 90 kgr./mm² (57.1 tons/sq. in.) and a minimum elongation of 10 %.

Finally, the *P. L. M.* Railways are trying a 0.3 % copper-steel rail in tunnels to reduce wear due to rusting.

No one reports the use of special steel in part of the rail section only.

b) The section and length of rails for main lines.

The growing stresses in the rails, set up by the ever increasing loads and speeds has led the railways to use longer rails of stronger section, in addition to improving the manufacturing methods and the quality of the steel.

The object of the large cross section is to increase the resistance of the rail to the static and dynamic forces set up in it by the rolling loads and to increase their life as regards wear, through contact with the wheels.

Longer rails, either as rolled or welded, reduce the number of joints, the shocks at which are the most serious cause of the disturbance of the track and damage to the rails. It has been found that over 80 % of the broken and damaged rails fail at the joints.

Table 8 summarises the replies received from the railways on which we report.

Rail sections. — All the railways use flat-bottomed rails on their main lines, with the one exception of the Midi lines which are laid with bull-headed rails.

The top of the rails is usually convex and the side faces inclined at 1 in 20 to the symmetrical axis so that the running face has the profile it tends to wear to.

TABLE 8.

Section and length of rails laid on the main lines.

ADMINISTRATIONS.	Section of rails. V = Vignole (flat-footed). B.H. = Bull-head.		Dimensions (in mm.).				Usual length laid.		Welding		
	Description.	Weight per linear metre.	*a*	*b*	*c*	*d*	New rails.	Re-used rails.	When used.	Lengths obtained and proposed.	Process used. — Remarks.
Bulgarian State.	V. Prussian 8 V	41 kgr. 34.82 kgr.	72 59	14 13.24	110 110	138 131	18 m.	...	Not used nor under consideration.	...	...
Egyptian State	V V V V	47 kgr. 46 kgr. 42 kgr. 37.4 kgr.	68 58 58 58	15 16 16 15	141 112 112 112	141 147 140 131	12 m.	...	As a trial : Goods line : 1 km. Suburban line : 1 km.	36-m. rails 1 000 m. of continuous track.	Resistance — welded in the works. Thermit welding — 47-kgr. track on metal sleepers with bolt and clip fastenings.
Northern of Spain	V	42.5 kgr.	62.5	15 5	131	134	12.40 m.; it is proposed to provide longer lengths.	...	Some trial lengths.	...	Thermit welding and electric butt welding.
Madrid, Saragossa and Alicante (M.Z.A.)	V V	45 kgr. 40 kgr.	66 60	15 15	130 126	142 130	12 m.	...	Not used nor under consideration.	...	...
Western of Spain	V. M.Z.A. type	45 kgr.	66	15	130	142	12 m.	...	Trials in tunnels and on metal bridges.	...	The methods to be used will be decided by the results of experiments.
Alsace-Lorraine	V. S. 33 V. S. 39 in tunnels	46.303 kgr. 55.695 kgr.	62 62	15 19	134 134	145 155	18 and 24 m.; 27 to 30-m. rails may be used in future.	41-kgr. rails : 21 m. (2 × 12 m. cropped and welded). 27 m. (2 × 15 m. cropped and welded).	Used in tunnels.	54 m., 60 and 90 m. under consideration.	Thermit welding. { Intercalary on sidings. Under compression on main lines.
French Est.	V. S. 33 V. S. 39 in tunnels	46.303 kgr. 55.695 kgr.	See above.				Running lines : 18 m. ; Certain bridges : 24 m.	...	Used in tunnels.	48 and 96 m.	Thermit welding: Intercalary or under compression : always annealed afterwards. Electric welding.
French State	V. S. 36 on most important main lines	50 kgr	65	15.5	140	153	Running lines 18 and 24 m. : bridges 18 to 24 m.	10 to 22 m.; not used on bridges nor in tunnels.	Used in tunnels.	72 m.	Thermit welding.
	V. S. 33	46.303 kgr.	See above.								
French Nord	V. S. 33 V. S. 39 in tunnels	46.303 kgr. 55.695 kgr.	See above.				18 and 24 m.	Not used on the main lines.	Used in tunnels : on steel bridges; in running roads as a trial.	From 48 to 288 m. Length of the structure. 35.334 m.	Thermit welding { Intercalary on sidings : By bringing the rails together under pressure and annealing on main lines. Resistance welding. Trial limited to 10 lengths of track with *Dupuy* type skew joints.

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TABLE 8. *(Continued.)*

ADMINISTRATIONS.	Section of rails. V = Vignole (flat-footed). B.H. = Bull-head.		Dimensions (in mm.).				Usual length laid.		Welding		
	Description.	Weight per linear metre.	*a*	*b*	*c*	*d*	New rails.	Re-used rails.	When used.	Lenghts obtained and proposed.	Process used. — Remarks.
Paris-Lyon-Méditerranée (P.L.M.)	V. S. 52	62.450 kgr.	70	17	158	178	24 m. on Paris-Ventimiglia line.	...	...	22 m.	Thermit welding on 100 rails. Electric welding under consideration.
	V. S. 39	55.695 kgr.	See above.								
	V. L. P.	47.824 kgr.	66	16	130	142	Other main lines : 18 m.				
	V. S. 33	46.303 kgr.	See above.								
P.O.-Midi (France)	*P.O.* : V. S. 33	46.303 kgr.	See above.				24 m. for 46-kgr. rails	...	Under consideration in tunnels.	...	Thermit welding.
	Midi : dissymmetrical bull-headed rails.	44.0114 kgr.	61	16	61	146	22 m. for 44-kgr. rails				
Algerian Rys.	Standard gauge V. L. P.	(P.L.M. type) 47.824 kgr.	See above.				12 m., 18 m. and 24 m.	...	Used in tunnels.	60 m.	Thermit welding. Trials of oxy-acetylene welding projected with the use of sole plates under the rail foot.
	Standard gauge V. S. 33	46.303 kgr.									
	Metre gauge V. S. 40	36.495 kgr.	58	13	115	128					
Tunisian Rys.	Standard gauge V. S. 12	46.02 kgr.	62	15	134	145	12 m.	Variable.	Used for trials especially on a bridge.	50 m.	Thermit welding.
	Standard gauge V. S. 40	36.495 kgr.	See above.						Extended use under consideration : in tunnels and on steel bridges.		Oxy-acetylene welding.
	Metre gauge V. S. 40	36.495 kgr.									
Colonial Railways in French West Africa	Standard (metre gauge)	30 kgr.	56	11	106	125.5	12 m.	...	Not used.	...	
Portuguese Rys.	V	45 kgr.	60	15	134	144	18 m.	...	Under consideration on steel bridges.	...	Oxy-acetylene welding.
	V	40 kgr.	60	15	125	131					
Rumanian State.	V	45 kgr., 40 kgr. 34.5 kgr.	...	...	...	...	15 m., 18 m., 20 m.	...	...	20 m. and longer rails.	Thermit welding.
Czechoslovak State.	V	49.71 kgr.	65.5	15	128	150	49.71 kgr. : 25 m.	...	Used or under consideration in certain cases.	...	Thermit welding in general use. Electric and oxy-acetylene welding under trial.
	V	44.35 kgr.	68	14	112	140	44.35 kgr. : 20 m.				
Turkish State.	V	39.52 kgr.	62	12	120	138	Running track : 12 m Certain bridges : 18 m.	...	Not used.	...	...
Jugoslav State	V. Reichsbahn S. 45*a*.	45.25 kgr.	67	14	125	142	S. 45*a* : 18 m. P. 8 : 15 m. Under consideration : 25 m.	...	Used on bridges.	Maximum 60 m.	Thermit welding : 2 000 joints welded. Böhler welding process : 12 joints being tested.
	V. Prussian 8	41 kgr.	72	14	110	138			In tunnels.	Maximum 1 200 m.	

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The main lines are laid as a rule with 5 to 50 kgr. (90.7 to 100.8 lb. per yard) rails. The *P. L. M.* however has been using for the last three years, on the Paris-Lyons-Marseilles-Ventimiglia line, standard S52 rails weighing 62.45 kgr. per m. (136 lb. per yard).

Length of rails as rolled. — The new rails now being laid are 12 m. to 25 m. (39′ 4 1/2″ to 82′ 1/4″) long. The *Alsace-Lorraine* intends using 27 to 30 m. (88′ 7″ to 98′ 5 1/8″) long rails in future.

Few railways relay on their main lines rails previously taken out of the track.

Welding. — Some railways are increasing the length by welding rails together. Up to now, this method is more used on sidings. On main-lines it is usually restricted to rails in tunnels or on steel bridges. On the latter the rails ought to be welded from one end of the bridge to the other and expansion joints provided near the free ends of the bridge. The length of welded rails in tunnels varies widely from one railway to another. The *Alsace-Lorraine* limits the length to 54 m. (177′ 2″), the *Est* to 96 m. (315′), the *Nord* to 288 m. (945′), and the *Yugoslav State* Railways have even welded a continuous length of 1 200 m. (3 937′) in the 1 838 m. (9 030′) long Braiditza tunnel. It seems quite practicable, therefore, to make the track continuous in tunnels where the temperature variation is small, by providing if need be, towards the tunnel ends, rails progressively decreasing in length down to the standard used in the running lines.

In the same way welding can be recommended for all parts of the permanent way where the effect of expansion is not feared : dead-end lines in terminal stations when the end can be considered as free to expand, tracks protected from direct sun rays by a roof, etc.

As regards the running track, the *French Nord* is making a test with welded rails 35.334 m. (99′ 6″) long with « Dupuy » special joints cut at an angle. Tests with 48-m. (157′ 5 3/4″) rails and special expansion joints (joints de dilatation à aiguilles) have just been made. The Egyptian State Railways have laid as a trial 1 km. (0.6 mile) of goods line with 36-m. (118′ 1 1/4″) rails obtained by electrically welding three 12-m. (39′ 4 1/2″) rails in the shops, and 1 km. welded from end to end on the Cairo-Helwan suburban line. In the latter case 144 m. (472 1/2′) long rails were assembled by alumino-thermic welding on the line side; they were then laid in the track on metal sleepers with clip and bolt fastenings, and these long rails were finally welded together during traffic breaks at night.

The alumino-thermic process is the one most widely used. Electric resistance welding is now being used by some railways and should have a great future.

The use of long rails with fewer joints should facilitate track maintenance and effect large savings. At the same time it should improve the comfort and riding of the stock and lengthen its life.

This question should be decided above all by the safety resulting from the stability and equilibrium of the track at all temperatures. This stability can only be obtained when the rails, no matter how long, are free to expand. The use of long rails is, in our opinion subordinated to the possibility of leaving the rail ends free to move so as to absorb the expansion occurring at high temperatures. This complex question has been studied in many ways and does not seem insoluble, provided a joint able to deal with considerable changes in length can be used. Suitable tests should be taken in hand on these lines and are likely to result in a satisfactory solution.

c) **The regulations governing the removal of rails from the track and the methods used to delay it.**

Table 9 contains the information the railways consulted supplied on their

practice as regards taking out rails from the main-lines, owing to vertical or lateral wear of the rail head or other defects. The rules in force embody the experience acquired by the railways in this matter.

The increased loads and higher speeds may tighten up the regulations as these increases stress the rails so much more severely. Rails which, up to the present, could be left in service without danger or other drawback will have to be taken out sooner, and the extent and cost of track maintenance will be increased. In order to lengthen the life of the rails, experiments have been made in building up the top of the rails by welding. The last column of Table 9 shows that electric welding is the method generally used, although the *Tunisian Railways* use oxyacetylene welding.

This method is used more especially in the case of points and crossings, where the crushing of the metal and wear is most marked through the shocks of the wheels passing over the gaps in the running surfaces.

The *French Nord* has built up rails for some time by this process and has extended its use to building up the ends of rails worn down or crushed by the wheel tyres. In the latter case after adding the metal the rail ends are carefully ground up so as to make the running surface at the joints level.

Rail joints.

a) Design of rails joints.

The joint, the assembly of the two rail ends butted together, is the weak point of the track. The running surface of the rail head is interrupted and the shocks set up as each wheel runs over the gap loosens the track round about the joint and ultimately wears and deforms the rail. These drawbacks become more marked as the weight and speed increase.

The information we have received on this particular part of the track is that the usual joint consists of fishplates bearing under the rail head and on the foot of the rail, and tightened by bolts through the web of the rail. The joint as a whole is supported by suitably arranged sleepers which are closer together at the ends of each rail. The fishplates are flat bars, angle bars, or with a foot, and are drilled with 4 or 6 holes.

The variety of detail arrangements of joints used by the railways bears witness to the efforts they have made to prevent too rapid wear and to ensure the track remaining in good order near the rail ends.

On fourteen out of the twenty railways replying, the rail ends are overhanging; the other six support them on a steel sole plate forming part of the joint assembly.

With the former arrangement the joint sleepers are 250 to 574 mm. (10″ to 1′ 10 5/8″) apart. It is not possible to say if there is any real advantage in making them touch and some of the railways who have tried this arrangement seem to be doubtful about adopting it.

The new joints tried by some of the railways do not appear to have given any definite results. The special joints reported in Report No. 2 on the resistance of rails to breakage and to wear at the Madrid Congress 1930 (*) such as the *Levaire* and the *chevron* fish-plates have not come into general use, nor has their use been extended on the railways who tried them.

However, the *French Est* uses on a large scale the type of joint with sole plates and wood packing described in the said report, the rail ends resting on a treated wood packing carried on the bearing plate.

The *French Nord* which used this type of joint for a time has given it up for the time being, but is now trying to make

(*) See *Bulletin of the Railway Congress*, October 1929.

TABLE 9.

Rules for removing the rails from the track and for building up worn rails.

V = Vertical wear
L = Lateral wear
} beyond which the rails are taken up.
This latter is usually measured 15 mm. below the running surface.

ADMINISTRATIONS.	Rules for taking up rails on the main lines.		Building up of rails.
	According to vertical and lateral wear of the rail heads.	For other causes : defects, damage.	
Bulgarian State.	No rule — withdrawn as decided by the sectional Engineer.		Not done.
Egyptian State	V = 12 mm. — No rule as regards L.	After examination in each case.	Arc-welding : rails in points and crossings.
Northern of Spain	V = 15 mm. — L resulting in the same reduction in strength as V = 15 mm.	...	Not done.
Madrid, Saragossa and Alicante	40-kgr. rails $V+\frac{L}{2} = 10$ mm. 45-kgr. rails $V+\frac{L}{2} = 14$ mm.	Visible defects which might affect the strength.	Not done.
Western of Spain	V = 10 mm. V + L = 20 mm.	After investigation, in each case.	Not done.
Alsace-Lorraine	46-kgr. and 55-kgr. rails $V+\frac{L}{2} = 16$ mm.	...	Used in points and crossings.
French Est.	46-kgr. and 55-kgr. rails $V+\frac{L}{2} = 16$ mm. *Short* rails L = 5 mm.	Withdrawn for defects recognised and defined by the railway.	Not done.
French State	46-kgr. and 50-kgr. rails $V+\frac{L}{2} = 16$ mm.	Rails with actual defects are withdrawn.	Not done.
French Nord	46-kgr. rails $V+\frac{L}{2} = 14$ mm. In tunnels $V+\frac{L}{2} = 10$ mm.	The rails are withdrawn when the wear other than on the top prevents the joints being made properly, or when it interferes with the rigidity and stability of the track.	The worn ends of rails on the main lines are built up by arc-welding.
Paris-Lyon-Méditerranée	$V + \frac{L}{2} = 14$ mm.	The rails, as a matter of principle, are withdrawn after 25 years' service on the Paris-Marseilles line, and after 30 to 40 on the other important lines in parts of the track where the number of breakages or defects justifies it.	Not done.
P.O.-Midi (France).	46-kgr. rails $V+\frac{L}{2} = 14$ mm. 44-kgr. bull-headed rails of the Midi $V+\frac{L}{2} = 15$ mm.	In practice the rails are withdrawn when the ends get worn, sometimes for apparent defects in the metal or cracks at the bolt holes.	Not done.
Algerian Rys.	L.P. and S. 33 rails $V+\frac{L}{2} = 14$ mm. 36-kgr. rails (metre gauge) $V+\frac{L}{2} = 11$ mm.	Withdrawn for visible cracks, or cracks revealed by tests, or when crushed.	Not done.
Tunisian Rys.	V = 5 mm. or L = 10 mm. Alteration of this rule under consideration, so as to take the inertia of the rails into account.	Visible defects that might affect safety.	Used in some particular cases: rails at crossings (standard gauge with tramway) — points and crossings and worn rail ends by oxy-acetylene welding.
Portuguese Rys.	V = 10 mm.	Corrugated or twisted rails, or rails with cracks or other defects in the running surface.	Rails are built up.
Rumanian State.	Withdrawn when the total wear is 10 % of the initial cross area.	Damaged rails are withdrawn.	Not done.
Czechoslovak State.	V + L such that the stress in the metal remains within reasonable limits.	Sometimes a systematic withdrawal after a specified period in service — and rails found to be defective.	A few tests made.
Turkish State.	Withdrawn as soon as the stress in the metal exceeds 1 200 kgr./cm2, which corresponds to V = 8 mm. for 39.52-kgr. rails.	When the running surface is broken up or for any other defect which might affect safety.	Not done.
Yugoslav State	Rails S. 45 V = 8 mm.	When defective or damaged.	...

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it less rigid by inserting a rubber pad between the rail ends and the metal sole plate.

This same railway is trying two new types of rail joint : one with flat ribbed fish-plates with 6 bolt holes, and the other of the *Dupuy* type, in which a metal block surrounds the two ends of the rails and holds them rigid on tightening up the thick fishplates free to slide on inclined planes to equalise the rigidity of each rail end. The moment of inertia of this type of joint is slightly greater than that of a continuous rail; the joint was designed to hold up the rail ends all the time whilst allowing them to expand more freely than an ordinary fishing. In addition no bolt holes have to be drilled through the ends of the rail, an improvement as these holes are frequently the origin of cracks in the web, which result in fractures under passing loads.

The *P. L. M.* uses a design of fish-plate with 6 holes based on those used on certain *American* railways for their 62.552 kgr./m. (130 lb. per yard) rails.

These trial types of fish-plate are under observation but it is too early for the railways using them to formulate any conclusions on them.

Table 10 summarises the information received in respect of the joints; the best types or those most frequently used are reproduced. A brief description is given of the maintenance methods and the arrangement of the sleepers at the joints as well as the opinions of the railways on the possible heat-treatment of the rail ends.

b) Width of rail joints.

The width of the gap between the rail ends has much to do with the loosening of the track caused by the passing wheels.

The railways who replied fix the width of the gap according to a simple formula based on the free expansion of the metal.

The gap J required at temperature t can be expressed by the relation :

$$J = C.\ L.\ (T\text{-}t)$$

in which C = coefficient of expansion,
L = Length of the rail;
T = Maximum temperature the rail can attain and beyond which it does not matter if there is no gap.

The selected values of C vary appreciably. The average values based on the information supplied are :

Bulgarian State	C = 0.000011.
Madrid-Saragossa-Alicante.	C = 0.000010792.
French Railways	C = 0.0000105.
Jugoslav State	C = 0.0000117.
Egyptian State	C = 0.000015.
Portuguese Railways . . .	C = 0.0000139.
Czechoslovak State . . .	C = 0.00001.

The highest rail temperature expected varies widely from one railway to another, especially between one country and another. In hot countries such as *Tunis*, and *French Western Africa*, it is some 80° C. (176° F.). The *Jugoslav State* and *French Railways* use 60° C. (140° F.) and the Czechoslovak State 50° C. (122° F.).

The actual gap is kept within the limits laid down in the regulations. Particular precautions have been taken against rail creep and stringent instructions are given to the local staff on the matter.

Table 11 gives particulars of the anti-creep devices in use, where used in the track, and the results obtained.

Not a single one of the arrangements tested appears able by itself to prevent creep entirely. The best method to prevent creep is to make the rail absolutely solid with the sleepers carrying it. The fastenings therefore must be kept really tight.

Assuming, however, the rails and sleepers to be perfectly fastened together, it is possible for the whole track to creep, the rails taking with them the sleepers which displace little by little the surrounding ballast.

The joint gaps, therefore, must be checked periodically in all cases, especially on the main-lines, and adjusted wherever they differ to any extent from those laid down in the regulations.

Some of the railways take special precautions to prevent the track getting suddenly out of line during very hot weather through the gaps closing up; special precautions are taken until normal conditions are restored.

On the *French Railways*, for example, these precautionary measures are enforced as soon as all the gaps on a length of at least 50 m. (164′ 1/2″) have disappeared.

The general conclusion from our examination is that the joint problem has not been solved in any way which fully meets the requirements of constantly increasing loads and speeds. Every improvement likely to lessen the stresses on the fishing, the rail ends, and the whole track near the joint should continue to be sought for.

Sleepers.

The sleepers act the double part of cross ties and supports. They tie the rails together through the fastenings, they keep the two files of rails fixed relatively to one another, and absorb the lateral thrusts of the vehicles.

They receive and transmit to the ballast the loads of the vehicles as well as the shocks and dynamic forces to which the rails are subjected.

The sleepers are subjected to stresses which increase rapidly as the loads and speeds.

The railways have met the effects of these growing loads and speeds by increasing the number of sleepers per rail length so as to distribute the load over a greater number of sleepers and to improve the grip of the sleepers in the track.

a) Laying plan and sleeper spacing.

The information supplied by the railways is summarised in table 12.

The closest sleeper spacing is found on railways permitting the heaviest axle loads and highest speeds.

On main-lines the normal laying plan provides for some 1 700 sleepers per km. (2 736 per mile).

On poor formations, in tunnels, and on sharp curves the *French State* and *Est* Railways space the sleepers more closely and use about 1 900 per km. (3 060 per mile).

This figure cannot be increased very much without making it really difficult to maintain and to level up the track.

Some railways employ various devices for increasing the transverse rigidity of the sleepering at places where the track is particularly prone to get out of line.

The *French Est*, for instance, has used recently on its main-lines flat bars 2.60 m. (8′ 6 3/8″) long, of 70 mm. × 7 mm. (2 3/4″ × 9/32″) section, screwed to the sleepers. The following table gives details of the use of these bars :

Radius of curves.	Parabolic transition from and to the curve.	Full curve.
R ⩽ 800 m. *(40 chains)*	The whole length of the parabolic transitions stiffened by crossed ties.	Stiffened by crossed ties at the joints; ties in V form between.
800 < R ⩽ 1200 m. *(60 chains)*	Mixed stiffening : crossed ties at the joints; ties in V form in the intervals.	No cross-bracing.
R > 1200 m.	No cross-bracing.	

TABLE 10

Joints and types of fishing.

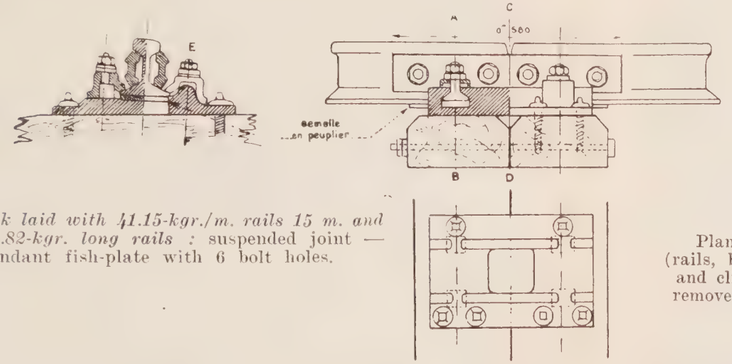
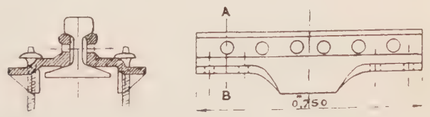
ADMINISTRATIONS.	Types of fishing used	Sleeper spacing at the joints.	Methods of maintaining the fishings — Stripping and examination.	Cleaning and oiling.	Replacement of materials.	Taking up wear on the fishing surface.	Heat treatment of rail ends.
Bulgarian State	*Track laid with 41.18-kgr./m., 18-m. long rails :* suspended joint resting on double sole plate fastened to two joint sleepers, touching one another, by 6 coach screws — Flat 4-bolt fish-plates. *Géo* fastenings (clips and bolts). (See sketch below.) 1/2 section A.B. 1/2 section C.D. 1/2 section E.F. 1/2 elevation.  *Track laid with 41.15-kgr./m. rails 15 m. and 34.82-kgr. long rails :* suspended joint — pendant fish-plate with 6 bolt holes. Plan (rails, bolts and clips removed).	*Track laid with 41-kgr./m. rails, 18 m. long :* a = 250 mm. } sleepers touching and bolted together. b = 627 mm. c = 750 mm. = d. *Track laid with 41-kgr./m. rails, 15 m. long, and 34.82 kgr./m. rails :* a = 530 mm. b = 693 mm. c = 770 mm. = d.	Periodical.	...	Yes.	No	Thought useful, but not done.
Egyptian State	*Track laid with 47-kgr. rails on wood sleepers :* suspended joint — flanged fish-plates with 6 bolt holes. (See sketch below.) Section A.B. Elevation. 	*Track laid with 47-kgr./m. rails on wood sleepers :* a = 574 mm. b = 628 mm. c = 678 mm. = d.	Constant supervision of fishings by staff going over the track.			Wedges used between the fish-plate and the rail head.	« Controlled cooling » of the whole rails is considered useful for preventing wear of the ends. Heat treatment of rail ends alone is not done.
Northern of Spain	Angle fish-plates 0.85 m. long, with 6 bolt holes.	$a < b < c$	During repairs.			...	Not done.
Madrid, Saragossa and Alicante	*Track laid with 45-kgr. rails :* angle fish-plates 0.70 m. long with 4 bolt holes. *Track laid with 40-kgr. rails :* angle fish-plates 0.80 m. long with 6 bolt holes. Suspended joints in both cases.	a = 420 mm.	Maintenance as needed.		As required.	No	Not done.
Western of Spain	4-hole angle fish-plate, 0.70 m. long.	a = 420 mm. b = 495 mm. c = 570 to 575 mm. } according as laid with d = 630 to 650 mm. } 18, 19 or 20 sleepers per 12 m. e = 630 to 740 mm. }	...	Done	...	No	Considered desirable but not in use.

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TABLE 10. *(Continued.)*

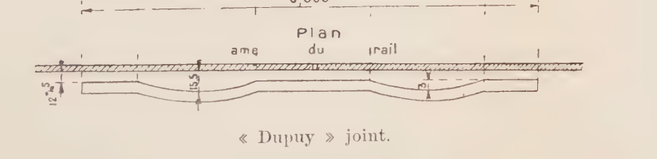
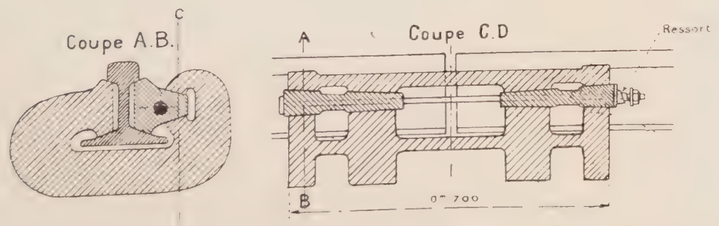
ADMINISTRATIONS.	Types of fishing used	Sleeper spacing at the joints.	Methods of maintaining the fishings				Heat treatment of rail ends.
			Stripping and examination.	Cleaning and oiling.	Replacement of materials.	Taking up wear on the fishing surface.	
Alsace-Lorraine	*Track laid with 46-kgr. rails* : suspended joints — standard flat fish-plates 0.58 m. long with 4 bolt holes.	a = 280 mm. { sleepers almost touching but not fastened together.	During complete overhaul.		When required.	Reconditioned fish-plates used.	Not done.
French Est.	*Track laid with 46-kgr. S. 33 rails* : supported joint with packing : fish-plates 0.58 m. long. (See section below.) Section.  (Creosoted hard wood packing.) (Resinified wood packing.)	*Track laid with 46-kgr./m. S. 33 rails 18 m. long* : a = 440 mm. b = 480 mm. c = 520 to 600 mm. d = 530 to 700 mm. e = 555 to 700 mm. } according as laid on the straight or on a curve.	Every 6 months.		When required.	Reconditioned fish-plates used.	Not done.
French State	*Track laid with 50-kgr. S. 36 rails* : suspended joints — angle fish-plates .	a = 280 mm. { sleepers almost touching but not fastened together. b = 540 to 560 mm. { according to closeness of sleepers.	During overhaul. Hammer-tested.	Oil mixed with graphite.	As required.	Use of wedges or reconditioned fish-plates.	Heat treatment of the whole rail appears to be preferable.
French Nord	*Track laid with 46 kgr. S. 33 rail* : suspended joint with standard 4-bolt flat fish-plates (as the Alsace-Lorraine). *Devices under trial.* supported joint with wood packing as on Est Ry. but without wood sole plate — sometimes rubber pad 2.5 mm. thick; joint with metal packing; supported or suspended joint with waved flat or angle fish-plates with 6 bolt holes (see sketch below); « *Dupuy* » boltless joint with square or skew rail ends (see sketch below). Waved flat fish-plates for suspended joint. Elevation. « Dupuy » joint.  *Note* : — Coupe = section. — Ressort = spring.	*Track laid with 46-kgr./m. 18 m. rails-standard laying* : a = 440 mm. b = 470 mm. c = 560 mm. d = 620 mm. When single rails are changed and flat fish plates used, the joint sleepers are almost touching but are frequently not assembled together with a = 280 mm.	Periodical.	Complete, periodically In addition fishing bearing surface oiled once a year with graphited oil or special grease in areas subject to acid fumes.	When required.	Use reconditioned fish-plates.	The question has not been raised.

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TABLE 10. *(Continued.)*

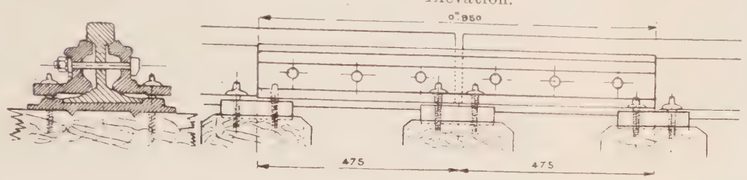
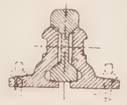
ADMINISTRATIONS.	Types of fishing used	Sleeper spacing at the joints.	Methods of maintaining the fishings				Heat treatment of rail ends.
			Stripping and examination.	Cleaning and oiling.	Replacement of materials.	Taking up wear on the fishing surface.	
Paris-Lyon-Méditerranée (P.L.M.)	*Track laid with 62-kgr. S. 52 rail :* joint carried by bearing plates on 3 sleepers — 6-hole angle fish-plates 0.95 m. long (see sketch below). *Track laid with L.P. or 46-kgr. S. 33 rail :* suspended joint — 4-hole angle fish-plates 0.48 m. and 0.545 m. long. Section. Elevation. 	*Track laid with 62-kgr./m. S. 52 rails* (see sketch) : L.P. or 46 kgr./m. S. 33 rails : *a* = variable from 260 mm. (sleepers touching), to 540 mm.	...	Lubricated with oil and graphite.	...	Uses packing or reformed fish-plates with the middle part rounded.	Test on 100 rails of surface hardening of the ends. The head and upper fishing surface
P.O.-Midi (France)	*Track laid with 46-kgr. S.33 rails :* suspended joint — standard angle fish-plates. *Track laid with 44-kgr. bull-headed Midi rails :* suspended joint — 6-hole bridge fish-plates 0.70 m. long. Section. 	*Track laid with 46-kgr./m. S. 33 rails :* *a* = 280 mm. *b* = 460 mm. *c* = 600 mm. *Midi 44-kgr./m. bull-headed rails :* *a* = 480 mm. *b* = 651 mm. *c* = 750 mm.	Each time the track is overhauled.		...	Use packings or reconditioned reformed fish-plates.	Question has not been considered.
Algerian Rys.	Use angle fish-plates exclusively.	Sleepers more closely spaced at joints. *Steel* sleepers : double joint sleepers. *Wood* sleepers : joint sleepers touching.	During overhaul.	... Oil and graphite.	...	Use packings.	Question not considered.
Tunisian Rys.	Standard 4-hole flat or angle fish-plates.	*Track laid with 46-kgr. S. 12 12-m. rails :* *a* = 425 mm. *b* = 590 mm. *c* = 800 mm.	During overhaul.			Use packings.	Question not considered.
Colonial Railways in French West Africa	30-kgr. standard 4-hole angle fish-plates.	*a* = 480 mm. *b* = 660 mm. *c* = 680 mm.	...	...	...	...	Not considered justified.
Portuguese Rys.	*Track laid with 45-kgr. m. rails :* suspended joints — 4-hole angle fish-plates 0.65 m. long, or : supported joint with wood packing.	Laid on 28 sleepers (per 18-m. length) / 30 sleepers (per 18-m. length) *a* = 490 mm. / 490 mm. *b* = 630 mm. / 574 mm. *c* = 650 mm. / 606 mm.	Complete overhaul every 2 years.	... Oil yearly during hottest weather.	...	Use packings.	Not used.

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TABLE 10. *(Continued.)*

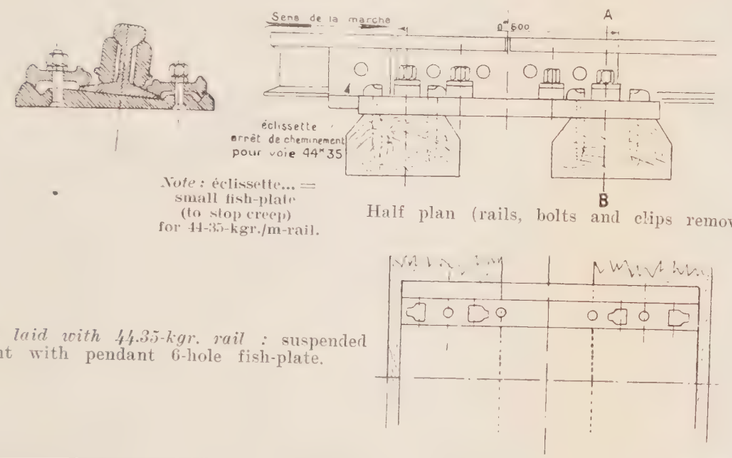
ADMINISTRATIONS.	Types of fishing used.	Sleeper spacing at the joints.	Methods of maintaining the fishings.				Heat treatment of rail ends.
			Stripping and examination.	Cleaning and oiling.	Replacement of materials.	Taking up wear on the fishing surface.	
Rumanian State.	Joint carried on double bearing plate itself fastened to 2 assembled joint sleepers (resembling the Bulgarian State pattern).	Sleeper joints touching and bolted together.	Not done periodically.		...	No	Not used.
Czechoslovak State.	*Track laid with 44.35 and 49.71-kgr./m. rail :* joint carried on bridge plate fastened to the sleepers on each side of the joint by 4 spikes. Fastened by bolts and clips; 4-hole flat fish-plates. (See sketch below.) Section A.B. Elevation. Direction of running.  *Note :* éclissette... = small fish-plate (to stop creep) for 44-35-kgr./m-rail. Half plan (rails, bolts and clips removed.) *Track laid with 44.35-kgr. rail :* suspended joint with pendant 6-hole fish-plate.	*Track laid with 49.71-kgr./m. rails :* 1360 sleepers per km. 1520 sleepers per km. a = 450 mm. 450 mm. b = 654 mm. 554 mm. c = 750 mm. 670 mm. *Track laid with 44.35-kgr./m. rails :* 1400 sleepers per km. 1500 sleepers per km. a = 480 mm. 480 mm. b = 639 mm. 584 mm. c = 730 mm. 680 mm.	When adjusting expansion gaps.	According to needs.	Reconditioned fish-plates under trial	Hardened rail ends thought an advantage but not introduced so far.
Turkish State.	Suspended joint, except on 23 km. of double-track line laid with the joints on double steel sleepers .	a = 390 mm. b = 630 to 660 mm. } according as laid with 15, 16, or 17 sleepers per 12 m. c = 740 to 860 mm. }	...	...	...	Use special angle-shaped packings (True Temper system).	Not done.
Jugoslav State	*Track laid with S. 45a or 8a rails :* joint carried on double sole plate fastened to the two joint sleepers bolted together — *Géo* fastenings — flat fish-plates (same joint as on the Bulgarian State Rys).	a = 250 mm. } Sleepers touching and bolted together. b = 579 mm. c = 800 mm.	Periodical.			Devices for taking up wear used.	Not done.
			...	Only bolts oiled.	...		

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TABLE 11.

Anti-creep devices.

ADMINISTRATIONS.	Devices used		Remarks about results obtained.
	Type.	Distribution.	
Bulgarian State.	Notched angle fish-plates. Stop in 2 pieces wedged under the foot of the rail.	6 per 15-m. 41-kgr. m. rail.	Satisfactory.
Egyptian State	Angle fish-plates held by coach screws and longitudinal and oblique flat bars tying together the 5 sleepers in front of joint. Various types of anti-creep devices.	1 fitting at each joint and 1 at the middle of each 12-m. length. Varies.	Too costly when new flat bars have to be used. Varies.
Northern of Spain	Stops in 2 pieces wedged to the rail foot.	...	Think of replacing them.
Madrid, Saragossa and Alicante	Stops in 2 pieces wedged to the rail foot.	...	Good result.
Western of Spain	45-kgr./m. rail : no device.	...	...
Alsace-Lorraine	Devices with 2 pieces wedged to the rail foot or angle stops, longitudinal bars connecting 7 sleepers.	1 per 18-m. rail at the middle. 2 per 21-m. rail } distributed over 3 per 27-m. rail } the length.	Effective results.
French Est.	Anchoring devices fastened to the rail foot. Several sleepers tied together by flat bars. In principle no device on the most up to date track.	1 or 2 per 18-m. rail.	Consider them useless and that creep can be prevented by keeping the coach screws really tight to prevent the rails moving on the sleepers.
French Nord.	Stop plates and bars when the track is laid on wood sleepers.	1 at the middle of each rail length.	Very effective.
French Ouest	Stops bolted to the web of the rail with bars tying together 5 or 6 sleepers. Stops in 1 or 2 pieces fastened to the rail foot by tension or wedging.	1 at the middle of each rail length. 3 per 18-m. rail } About the middle. 4 per 24-m. rail }	Satisfactory.
Paris-Lyon-Méditerranée	Stop plates in old lines. Brackets in new lines. Devices in one piece secured under the rail foot on test.	7 per 18-m. rail } About the middle. 9 per 24-m. rail }	...

ADMINISTRATION.	Devices used		Remarks about results obtained.
	Type.	Distribution.	
P.O.-Midi (France).	Brackets bolted to the rail and bar tying together 5 sleepers with Vignole rails. Two-piece device wedged to the rail on track laid with bull-headed rail.	1 at the middle of each length.	Satisfactory, provided the coach screws are well tightened.
Algerian Rys.	Stop plates or brackets.	About the middle, number varies according to the speed and gradient.	—
Tunisian Rys.	Track laid with : 46-kgr./m. S. 12 rails : ribbed fish-plate and flanged coach screws. 36-kgr./m. S. 40 rails : bracket stops alone or with ribbed fish-plates. Other patterns of track : various devices.	1 at each joint. 4 per 12-m. length.	Not always good enough to prevent creep.
Colonial Railways in French West Africa	Various types have been tested and then abandoned.		The experiments commenced on the single lines are not yet entirely to hand.
Portuguese Rys.	Two-piece devices wedged to the rail foot and bars tying together 4 sleepers.	1 at one third of each length.	Does not prevent creep but reduces it considerably.
Mozambique Rys.	Angle fish-plates and coach screws, and rails wedged.	—	Good results.
Rumanian State.	Joint fish-plates and intermediate fish-plates coach-screwed to the sleepers.	—	Does not give satisfactory results.
Czechoslovak State.	Track laid with : 44.35 kgr./m. rails : short fish-plate near the joint butted against the bridge plate or notched angle fish-plate with downward extension. 49.71 kgr./m. rails : no special device (very rigid fastenings).	1 at each joint.	—
Turkish State.	Anti-creep blocks.	4 or 6 per 12-m. length.	Not sufficient results.
Jugoslav State	Track laid with S. 45 *a* rails : no special device. (Very rigid Geo fastenings). Other rails : 2-piece device bolted under the rail foot or one-piece device fastened under the rail foot.	About the middle, number varies according to amount of creep.	

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TABLE 12.

Kind and spacing of sleepers used in main-line tracks.

ADMINISTRATIONS.	Number of sleepers per rail length.	Maximum number of sleepers per kilometre.	Kind of sleepers used.
Bulgarian State.	25 sleepers per 18 m.	1 334	Untreated oak and treated beech.
Egyptian State	18 or 19 sleepers per 12 m.	1 583	Prefer metal or eucalyptus wood.
Northern of Spain	Sleepers spaced from 0.56 to 0.75 m.	1 613	Untreated oak, treated beech and pine.
Madrid, Saragossa and Alicante	18 to 20 sleepers per 12 m.	1 667	Untreated oak, treated beech and pine.
Western of Spain	18, 19 or 20 sleepers per 12 m.	1 667	Untreated oak, treated pine, and tropical timber under test.
Alsace-Lorraine	30 sleepers per 18 m. 40 sleepers per 24 m. 44 sleepers per 27 m.	1 667	Treated beech and oak; metal.
French Est.	30 to 33 sleepers per 18 m. In tunnels : 44 sleepers per 24 m.	1 883	Treated hard wood. Trials in hand of reinforced concrete sleepers, Cotrab and Vagneux systems.
French State	31 or 33 sleepers per 18 m.	1 883	Treated hard wood on main lines ; steel sleepers on other lines except near the coast.
French Nord	30 or 32 sleepers per 18 m. 40 or 42 sleepers per 24 m.	1 778	Treated hard wood on the main lines. Limited use of metal and reinforced concrete sleepers on other lines.
Paris-Lyon-Méditerranée (P.L.M.)	27 to 31 sleepers per 18 m. 31 to 41 sleepers per 24 m.	1 722	Treated hard wood on main lines. Vagneux reinforced concrete sleepers on sand ballast. Steel on lines on which the speeds $\leqslant$ 90 km./h. Michel type (Compound iron and wood).
P.O.-Midi (France).	Vignole rails : 41 sleepers per 24 m. Bull-headed rails : 34 sleepers per 22 m.	1 707 1 543	Treated hard or soft wood. Reinforced concrete Orion and composite type on the Midi.
Algerian Rys.	27 sleepers per 18 m. 36 sleepers per 24 m.	1 500	Steel, and reinforced concrete (Vagneux type) under trial.
Tunisian Rys. — Standard gauge	16 to 20 sleepers per 12 m.	1 667	Untreated Zéen oak. Steel.
Tunisian Rys. — Metre gauge.	13 to 16 metal sleepers per 9.60 m.	1 600	Vagneux reinforced concrete sleepers under test.
Colonial Railways in French West Africa	Metre gauge : 18 sleepers per 12 m.	1 500	Standard pea-pod metal sleepers weighing 44.5 kgr.
Portuguese Rys.	28 or 30 sleepers per 18 m.	1 667	Untreated oak or eucalyptus, and treated pine.
Mozambique Rys.	23 sleepers per 18 m.	1 277	Untreated wood.
Rumanian State.	23 or 26 sleepers per 15 m.	1 734	Untreated oak and treated beech.
Czechoslovak State.	34 or 38 sleepers per 25 m. 28 or 30 sleepers per 20 m.	1 520	Treated hard wood, either oak or beech; metal sleepers under test since 1935.
Turkish State.	...	...	Metal until 1930. Now treated beech solely in the ordinary track and untreated oak under all points and crossings.
Jugoslav State	26 or 27 sleepers per 18 m.	1 500	Untreated or treated oak, treated beech, treated pine rarely. Steel sleepers under the points and crossings.

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The *Alsace-Lorraine* and *French State* Railways are considering the use of such cross-bracing on small-radius curves on main-lines.

b) **Nature and characteristics of sleepers.**

Nearly all the railways use on their main-lines wooden sleepers which they definitely prefer to any other.

The wooden sleeper is undoubtedly the best for high speeds because of its flexibility and the way it stands up under the various loads of the passing vehicles.

Hard woods such as oak and beech are usually used on main-lines, but the choice is often governed by economic or transport reasons. The dimensions of sleepers for main-line use are much the same on all the railways :

length 2.50 to 2.70 m. (8′ 2 7/16″ to 8′ 10 5/16″),

width 0.24 to 0.30 m. (9 7/16″ to 11 13/16″), and

average thickness 0.15 m. (6″).

Almost all railways impregnate wooden sleepers either wholly or partly with creosote, shale oil, copper sulphide, or zinc chloride to protect them against decay and lengthen their life.

The *Egyptian State, Tunisian, French West African* and *Mozambique Railways,* however, use untreated sleepers owing to the very dry climate of the countries in which they are used.

The impregnating methods have not undergone any great change and consist of simple immersion or treatment by the well known *Bethell* or *Rueping* processes.

The average life of a sleeper under heavy traffic is about 25 years.

Some railways on which the speeds are not very high, such as the *Egyptian State* and the *Colonial* lines of *French West Africa* prefer metal sleepers in very dry districts as their life is longer and they are not subject to the attack of destructive agents, such as insects.

So far it is impracticable to express any firm opinion on reinforced concrete sleepers. All the trials made retain the characteristics of large-scale, but limited experiments. Concrete does not appear to adapt itself very well to the repeated stresses set up in the track by passing loads nor to stand the fatigue induced in the material they are made of.

The mixed steel and concrete design seems to stand up best on the most heavily loaded lines.

This is the only design, moreover, that has given any satisfaction.

The mixed wood-and-iron sleepers tried on a large scale have not stood heavy loads nor high speeds; they are being withdrawn gradually from service.

Rail fastenings.

The stresses in the rail fastenings have been raised appreciably by the increase in speed and load. Then too, as we have seen, the fastenings have much to do with rail creep. The rail fastenings on main lines with fast heavy traffic must be therefore very strong, readily repaired, and kept always tight.

In order to ascertain the actual progress made in this field we asked the railways certain questions and the replies received have been summarised in Table 13.

The multiple static and dynamic stresses set up by the passage of heavily loaded axles of vehicles running at high speeds seems to cause the railways to better distribute the bearing of the rail on the sleeper by a modification of the rail fastening. Soft wood, treated wood, tarred jute, felt, or rubber pads have been fitted between the foot of the rail and the sleeper, with encouraging results.

Most of the railways, however, appear to think the best method of preventing any movement between the rail and the sleepers is to use large-area sole plates between the rail foot and the top of the sleeper.

The high stresses in the rail due to the increased loads and speeds tend to lift the rail foot and displace it relatively to the sleepers. This throws a load on the coach screws and gradually damages the wood where the rail bears on it.

The metal sole plate distributes the pressure from the axles over a large area, prevents this wear, and so reduces the gradual forcing of the rail into the sleeper. It also reduces the movement of the rail, and the track is kept in line and to gauge more easily. For these reasons the tests made by the railways formerly laying their rails directly on the sleepers have been made first on curves, whereon the lateral thrusts and vertical loads are the most variable and severe.

Fifteen out of twenty railways use this sort of fastening on their main-lines; ten use it generally, three others on small-radius curves, and two are making trials.

Three of the thirteen railways using bearing plates interpose between the rail and the bearing plate a further plate with some elasticity in order to prevent the hammering which occurs if any play develops between the rail and the bearing.

The *Bulgarian* and *Jugoslav* State Railways use poplar packings, and the *P.L.M.* rubber. The *Western of Spain* uses felt pads but only in some tunnels.

As a rule the steel bearing plates are secured by the same 4, 6 or 8 coach screws used to hold down the rails to each sleeper.

Some railways, including the *Bulgarian, Czechoslovakian* and *Jugoslav State* Railways duplicate the fastenings, the plate being coach-screwed to the sleepers and the rail secured to the plate by bolts, clips, wedges, keys, or other suitable means. Table 10 shows these arrangements in section.

The *French Nord* has carried out experiments on a limited scale with welded wedge plates on steel sleepers, but no conclusions can be expressed thereon at present.

In trials of some importance of reinforced concrete sleepers, the rails have been held by coach screws screwed into suitable fittings embedded in the concrete, such as steel spirals, or cast iron or wood sockets. Wood or rubber packings are always interposed between the rail and the sleeper when concrete sleepers are used.

Such packings, made of ordinary poplar, treated wood, or rubber, are used on a large scale by the *French Nord* and *Es* Railways with wood sleepers on their most heavily loaded sections.

To sum up, the type of fastening is still a matter of argument, investigation or opinion.

We think, it should include a large bearing plate to prevent the rail being driven into the wood under present axle loads, and the fastenings of rail to bearing plate and bearing plate to sleeper should be independent.

Ballast.

The ballast is the layer of compact homogeneous material distributing over the surface of the formation the rolling loads, carried by the rails and sleepers. In addition it ensures by its adhesion to the rails and sleepers the lateral stability of the track, and by its mass in which the sleepers are embedded hinders any possible movement thereof. It has to be permeable so that water can pass through it quickly to the formation where it is either absorbed or carried away by the drainage provided. It has to be easily handled and by its nature lend itself to the work of restoring and holding the track to the correct level.

The information supplied by the many railways on the ballast they use on their main-lines can be summarised as follows :

Broken hard stone or furnace slag is almost exclusively used in relaying or making up the ballast on the main-lines.

TABLE 13.

Rail fastenings.

ADMINISTRATIONS.	Types of fastening used.	Use of metal bearing plates on wood sleepers.	Use of packing pads	
			On wood sleepers.	On metal or concrete sleepers.
Bulgarian State.	*(a)* Ordinary bearing plate drilled for 3 coach screws. *(b)* Ribbed bearing plate fastened to the sleeper with 3 coach screws, rail bolted and clipped to the plate. (*Géo* fastenings). *(c)* At the joints, double ribbed bearing plate.	Bearing plates *(a)* and *(b)* alternately or bearing plates *(b)* alone (on curves R $\leqslant$ 300 m. and down gradient $\geqslant$ 1 in 100) are used generally.	Poplar pads generally used between the rail foot and type *(b)* and *(c)* bearing plates.	...
Egyptian State	On metal sleepers : bolts and clips. On wood sleepers : metal bearing plate ordinarily with three coach-screw holes.	In general use.	Not used.	Not used.
Northern of Spain	Ordinary steel bearing plate with 3 coach-screw holes.	In general use.	Not used.	...
Madrid, Saragossa and Alicante	Ordinary steel plate and coach screws.	In general use.	Not used.	...
Western of Spain	Ordinary metal bearing plate with 4 coach screws on the joint sleepers and with 3 coach screws on the intermediate sleepers.	In general use.	Felt pad used between the rail and the bearing plate in some tunnels.	...
Alsace-Lorraine	On wood sleepers : 6 coach screws per sleeper with or without metal bearing plates. On metal sleepers : bolts and clips.	In general use on : 1. The old track; 2. The standard track on curves of R $<$ 900 m. and on lines with many curves.	Not used except on old lines laid with S. 12 rails, when poplar packings are used.	Not used.
French Est.	6 coach screws per intermediate sleeper. 8 coach screws per joint sleeper.	Bearing plates are not used.	Compressed resinified poplar packings used in maintenance work alone.	Rubber pads being tried on concrete sleepers. First results are satisfactory.
French State	On wood sleepers : coach screws. On metal sleepers : bolts and clips.	Bearing plates are not used, except as a trial on the main lines.	Not used.	Rubber. bakelised wood, and asphalted jute packings on concrete sleepers — rubber appears the best.
French Nord	On wood sleepers : 6 galvanised coach screws per sleeper. On metal sleepers : bolts and clips or welded plates and keys (*Ougrée* type) or welded ribbed plates (*Géo* type). On concrete sleepers coach screws into *Thiollier* spirals or cast iron sockets.	Bearing plates are not used except for a trial or sharp curves (keyed bearing plates).	2.5 mm. indiarubber pads used in maintenance work or, when joints with packings are used, between the rail and the bridge bearing plate.	Wood packing generally used. Rubber pads being tried on concrete sleepers. Rubber used on metal sleepers in maintenance work.

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TABLE 13. *(Continued.)*

ADMINISTRATIONS.	Types of fastening used.	Use of metal bearing plates on wood sleepers.	Use of packing pads	
			On wood sleepers.	On metal or concrete sleepers.
Paris-Lyon-Méditerranée . . . (P.L.M.)	On wood sleepers : 8 coach screws per sleeper with ordinary bearing plates. On metal sleepers : bolts and clips. On concrete sleepers : coach screws and spirals.	Generally used except on standard track, laid up to 1930.	Rubber pads used when the line is laid on bearing plates and bakelised poplar packings, when the line is laid without bearing plates.	Rubber pads on metal sleepers. Rubber or poplar packings on concrete sleepers.
P.O.-Midi (France).	Flat-bottomed rails : coach screws with or without bearing plate. Bull-headed rails : chairs and keys.	Bearing plates in general use when the curves R $\leqslant$ 400 m.	Only used experimentally.	Wood packings used on concrete sleepers — their life is short.
Algerian Rys.	On wood and concrete sleepers : coach screws. On metal sleepers : bolts and clips.	Generally used.	Not used.	Wood or rubber packing used on concrete sleepers — rubber appears to give satisfactory results especially at the joints.
Tunisian Rys	On wood sleepers : 8 coach screws per joint sleeper, 4 coach screws on the intermediate sleepers. On metal sleepers : bolts and clips.	Bearing plates are not used.	Not used. A trial with rubber pads and bakelised wood on joint sleepers is under consideration.	Trials of poplar packings on metal sleepers unsatisfactory.
Colonial Railways in French West Africa	Metal sleepers : bolts and clips.	...	...	Not used.
Portuguese Railways and Mozambique Rys.	6 coach screws per sleeper.	Bearing plates are not used.	Not used.	...
Rumanian State.	Bearing plates, flanges, and coach screws.	Use general on all main lines.	Not used.	...
Czechoslovak State	On wood sleepers : bearing plates fastened to the sleepers by coach screws or spikes; rail fastened to the bearing plate by means of 2 bolts and 2 clips. On metal sleepers *(trial)* : bolts and clips.	In general use except in tunnels.	Not used.	Special wood packings used on metal sleepers experimentally.
Turkish State	On wood sleepers : coach screws with or without bearing plates. On metal sleepers : bolts, studs and clips — or bolts, studs and bearing plates.	In general use at joints and on curves of R $\leqslant$ 400 m.	Not used.	Use poplar packings on some metal sleepers — there is a tendency to slide.
Jugoslav State	Same fastening as on the Bulgarian State.	In general use.	6-mm. poplar packings between the rail and the bearing plate. Felt packings on metal bridges with rails laid directly on the girders.	

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The ballast is screened so that its dimensions are between 15 and 80 mm. (5/8″ and 3 1/8″).

The *Northern of Spain* Railway uses 40-80 mm. (1 9/16″ — 3 1/8″) ballast. The *French Nord* uses 15-40 mm. (5/8″ — 1 9/16″) ballast for the top layer 5 to 10 cm. (2″ to 4″) thick, and for levelling purposes, and in some cases porphyry chips only some 10 mm. (3/8″) in size.

Railways on which the line is levelled by shovel packing use either screened small ballast specially supplied for the purpose, or the small top layer ballast.

Most railways do not test ballast before purchase but are content to specify the nature, source, size, and sometimes the specific weight and other qualities.

Other railways, such as the *Czechoslovak* and *Jugoslav* State insist on the ballast passing specified tests.

Table 14 gives the section through the ballast on the main-lines of the different countries. It should be noted that some railways use an under layer of relatively fine material, such as sand, gravel, or ashes, put down when laying the track, others the old relatively large-sized ballast contained in it.

Some railways such as the *Czechoslovak State* Railways, when renewing the whole of the ballast, thoroughly roll it before relaying the track.

The general conclusions of this review are :

— the general tendency on the main-lines is to use about 50 cm. (20″) of ballast between the formation and the underside of the sleepers;

— the existing ballast is retained in place as a stable and resistant underlayer between the bed and the newly added layer of ballast on the track;

— broken hard stone which can be tamped or shovel-packed into a compact and resistant conglomerate under the sleepers is being used almost solely;

— the size of the ballast is kept down to between 60 and 80 mm. (2 3/8″ and 3 1/8″) and there is a tendency to avoid mixing small ballast with coarse;

— some railways, such as the *French Nord,* use on an extensive scale a top layer of finer ballast for the final levelling of the track and for making-up purposes.

Formation.

The formation is the natural support to which the various forces set up by passing vehicles are transmitted. It, therefore, in the last resort has to stand all the pressure and should be the unchanging foundation of the permanent way.

The increase in the total weight of the vehicles and the axle loads has in some cases disturbed the formation and caused it to sink progressively on sections where the ground was unstable or waterlogged.

The remedy in such cases is to consolidate the ground and above all drain it properly.

The top of the formation on most railways is sloped 2 to 5 % to the outside, so as to let all water getting through the ballast drain away more easily.

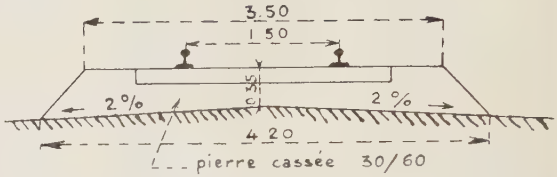
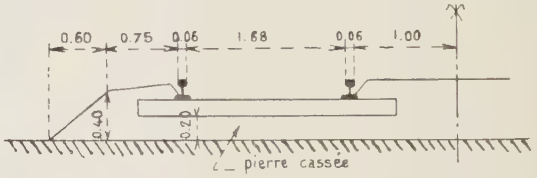
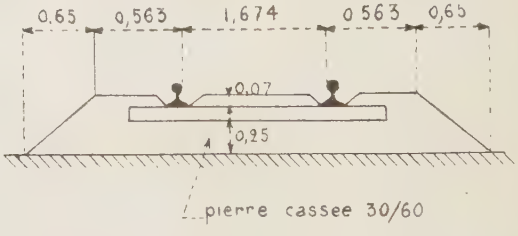
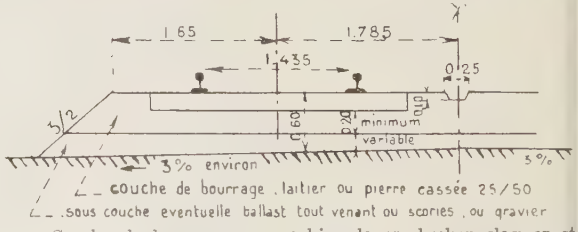
Several railways cover the bed when making it with an underlayer of fine material, sand, ashes or clinker, 15 to 25 cm. (10″) thick. This practice increases the depth of the ballast and by distributing the pressure more evenly reduces the load on the bed and prevents the ballast being driven into the bed. When the ground is soft or likely to become so when wet, drains can be arranged through this layer of fine material to collect the water and discharge it into ditches alongside the line. This layer moreover acts as an insulating and absorbent mattress spread over the unstable ground which it covers without penetrating it and preserves it from wet.

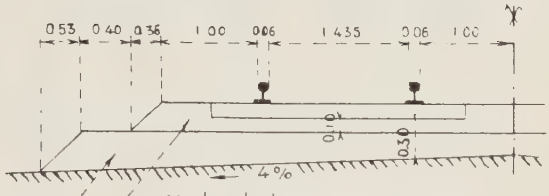
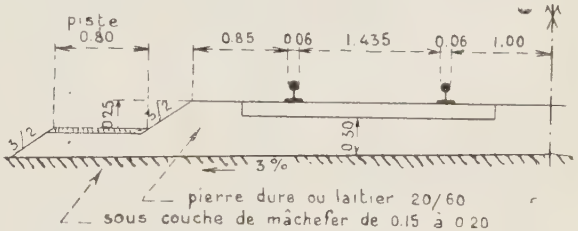
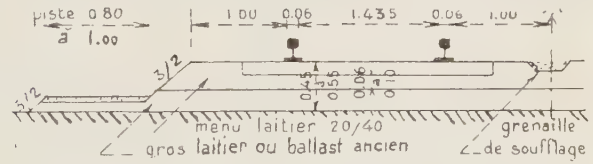
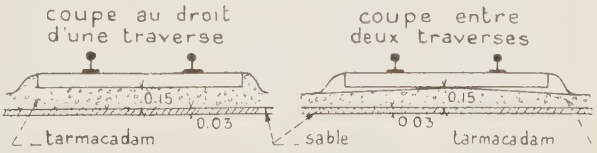
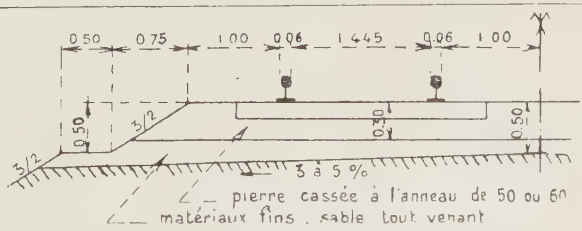
These steps can be completed by small retaining walls, stone facings, ditches, culverts, etc...

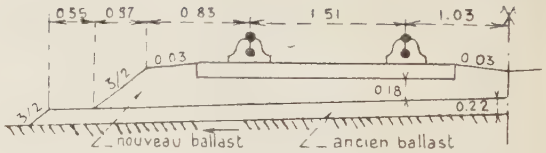
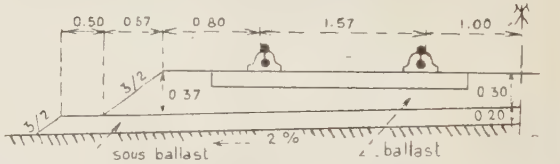
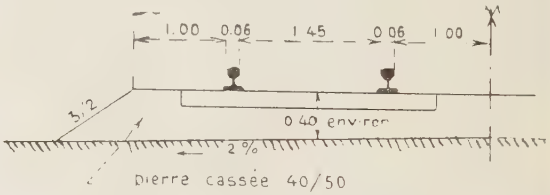
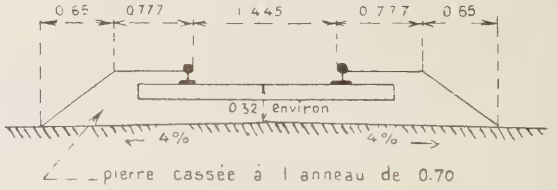
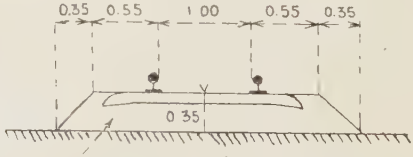
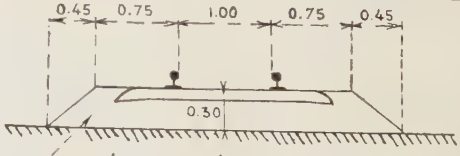
The thin layer of concrete tried experimentally on some railways has not

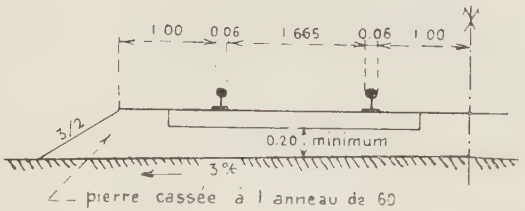
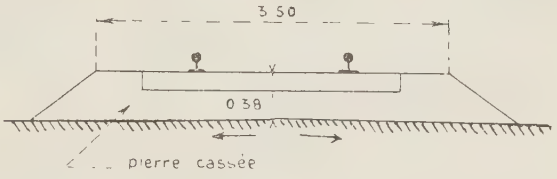
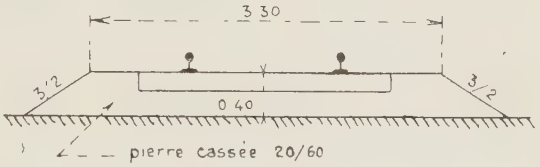
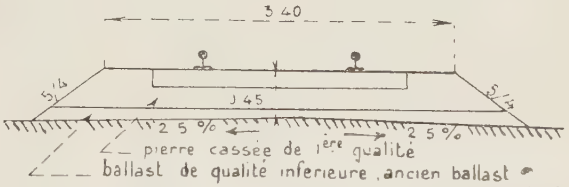
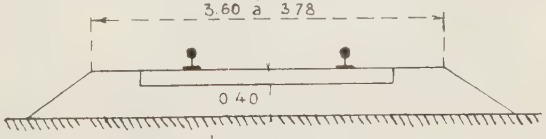
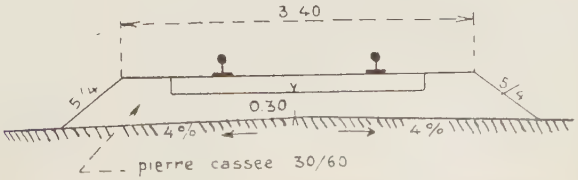
TABLE 14.

Sections through ballast.

ADMINISTRATIONS.	Main-line ballasting.
Bulgarian State.	 *Note.* — Pierre cassée 30/60 = 30-mm./60-mm. broken stone.
Egyptian State	Ballast of one material used in a single layer of 0.20 m. t 0.40 m. under the sleepers.
Northern of Spain	Gauge = 1.674 m. (5′ 6″). 40 mm./80 mm. broken ston used in a single layer 0.20 m. deep under the sleepers.
Madrid, Saragossa and Alicante	
Western of Spain	
Alsace-Lorraine	 *Note.* — Couche de bourrage... = packing layer, broken slag or sto 25-mm./50-mm.; under layer when needed, ordinary ballast, cind or gravel.

ADMINISTRATIONS.	Main-line ballasting.
French Est.	 *Note.* — Couche de... = packing layer. — Sous-couche... = under layer in clinker, gravel.
French State	 *Note.* — Pierre dure... = hard stone or slag 20-mm./60-mm. — Sous-couche... = under layer of clinker of 0.15 to 0.20 m.
French Nord . Usual section .	
Paris station type section. .	 *Note.* — Menu laitier = small 20-mm./40-mm. slag. — Grenaille de soufflage = small material for shovel packing. — Gros laitier = coarse slag or old ballast. — Coupe au droit... = section in line with a sleeper. — Coupe entre... = section between two sleepers. — Sable = sand.
Paris-Lyon-Méditerranée . . . (P.L.M.).	 *Note.* — Pierre cassée... = broken stone to pass a 50-mm. or 60-mm. ring. Matériaux fins... = fine material, unsifted sand.

ADMINISTRATIONS.	Main-line ballasting.
Midi	
P.O.	
	Note — Nouveau (ancien) ballast = new (old) ballast. — Sous ballast = under ballast.
Algerian Rys.	
Tunisian Rys. — Standard gauge .	
Tunisian Rys. — Metre gauge. . .	
	Note. — Pierre cassée... = broken stone to pass a 70- mm. ring.
Colonial Railways in French West Africa . . . . . Metre gauge.	
	Note. — Grès cassé... = broken sandstone to pass a 50-mm. ring.

ADMINISTRATIONS.	Main-line ballasting.
Portuguese Rys.	
Mozambique Rys.	
Rumanian State.	
Czechoslovak State.	 *Note.* — Pierre cassée... = first grade broken stone. — Ballast de qualité... = low grade ballast — old ballast.
Turkish State.	
Jugoslav State	

been altogether satisfactory, and consequently has not come into general use. None of the railways consulted dealt with them in their reply. The *Alsace-Lorraine* Railways, however, report their intention of trying « tarmacadam » which consists of broken stone, gravel or blast furnace slag coated with tar so as to provide a waterproof layer over the formation. Above this they propose to lay 50 cm. (20″) of ashes over which the track with its usual thickness of ballast will be laid.

The *French* Nord made an interesting innovation when rearranging the Paris terminus in ballasting the track in a zone wherein very many movements — at low speed, it is true — of locomotives with very heavy axle loads take place, with much braking and slipping. The formation soon becomes very soft when wet. The top layer of the track was therefore laid in tarmacadam. The track and connections are thereby laid directly on an impermeable layer, the top of which is suitably sloped to drain surface water to the sumps and drains.

By its very nature this layer is flexible enough not to break or crack when vehicles run over it and is giving complete satisfaction. The sleepers are blocked up at the ends but the space between them has not been filled and has saved much material without the slightest disadvantage.

Bridges and other structures.

In Chapter I we pointed out how the effect of heavy loads moving at high speeds was allowed for in calculating metal or reinforced concrete bridges.

The railways consulted have supplied much interesting data. In addition to the permanent loads, the rolling loads of a standard train are taken as averaging as much as 10 tons per metre (3 tons per foot) and are multiplied by an impact constant C given by formulae such as :

— *Egyptian State Railways :*

$$C = 1 + \frac{36}{27 + L}$$

— *French main lines :*

$$C = 1 + \frac{0.4}{1 + 0.2\,L} + \frac{0.6}{1 + \frac{4\,P}{S}}$$

L being the length of the girder or span considered,

P the total permanent load carried,

S the total rolling load it may have to carry.

Some railways take other influences into account in the formula : for example the *Egyptian State* Railways evaluate the lateral impact and the braking forces respectively at 1/4 the axle load and 1/7 of the rolling load.

The object of these formulae is to take into account the effect of the weight of vehicles at speed, an effect which obviously cannot but increase as the fast heavy traffic of the main line railways is developed.

In the preceding chapter we saw the importance of continuing experimental work so that the actual stress on the different parts of the track due to the passage of the heaviest trains or vehicles can be ascertained and measured by instruments such as strainmeters, deflectometers, etc...

There is no doubt but that such measurements would enable us to determine the actual effect, under equal loads, of the different speeds at which are operated separate vehicles such as railcars or the ever increasingly heavy locomotives or trains now running over the main-lines.

If this effect in terms of the speed as well as of the axle loads were known, the actual consequences on masonry bridges — some of which have been damaged by using heavier engines and

have had to be consolidated and reinforced — could be ascertained.

The railways were asked if they had had to alter and reinforce the track over bridges owing to the new traffic conditions.

The replies received show that the method preferred is to ballast the track on bridges. On masonry bridges 60 cm. (2′) of ballast is used under the sleepers, this possibly including an underlayer of sand or gravel. The thickness is often only 20 to 45 cm. (8″ to 17 3/4″) on steel or reinforced concrete bridges.

The length of the rails, no matter how the line is laid, is arranged to bring the joints over or very near the supports. Welded rails are being more and more widely used on long bridges so as to reduce or eliminate as far as possible blows from the tyres over the whole length of the structure.

Elastic packings of felt or indiarubber are used between the rails and the wood or metal to which they are fastened. The use of rubber, as we have already pointed out, appears to be growing.

Finally, to minimise the consequence of a derailment on or near a bridge, several railways either generally or at particular points, such as curves, down gradients, etc... use check rails or guiding angles and occasionally in front of the bridge re-railers to prevent any derailed pair of wheels leaving the track near or on the bridge.

Curves.

The running of fast trains over the railways depends in the first instance on the layout of the line. Many delicate problems are raised in running over curves and the solutions depend on the knowledge and experience of the permanent-way engineers.

a) Gauge on curves.

Vehicles are as a rule enabled to negotiate sharp curves by widening of the gauge. This problem hardly arises from the point of view under consideration as high speeds are only possible over curves of such radius as to require no widening. Moreover the vehicles and trains for high-speed services are given sufficient play or have sub-frames, bogies or trucks as pointed out in Chapter I, which avoids any difficulty in this respect.

Table 15 summarises the information the railways consulted supplied on gauge widening on curves in terms of the radius. The recent tendency on many railways to close in the gauge on curves and the straight, to reduce the lateral play between the flange and the rail and so restrict hunting, should be noted. Some railways retain the standard gauge on curves down to 500 m. (25 chains) radius. Other railways such as the *Jugoslav State* and *Alsace-Lorraine* are considering a reduction in the amount the gauge is now widened. The latter Administration considers curves of 300 m. (15 chains) can be laid without gauge widening; this is the present practice of the *Rumanian State* Railways.

b) Layout of the track on curves.

The correct layout and gradient section of the track throughout a curve and its approaches is quite another matter.

A vehicle at high speed can only change its position progressively and without shock when suitably guided onto, through and off a curve. It is guided by a suitable layout and its position relatively to the track is determined by the superelevation (cant), i. e. the difference in level of the two rails.

When on the curve itself all that is needed is to keep the circular curve regular and the correct cant constant. The transition to or from the curve should be properly laid with increasing or decreasing curvature and cant.

The simplest and most frequently used transition is that in which the curvature

increases linearly with the distance. This is a cubic parabola defined by the equation :

$$y = \frac{x^3}{6\ LR}$$

x and y being the abscissæ and ordinates relatively to the straight section, R the radius of the curve, and L the length of the parabolic transition generally governed, as we shall see later on, by the amount of superelevation.

Table 16 shows that this cubic parabola is used by most railways, sometimes with variants, for the transition between a straight section and a circular curve. Some railways also lay between two circular compound curves an arc of a cubic parabola osculatory to each of the two circular curves. Finally two reverse curves can also be connected by two parabolas of the third degree. These two parabolas, of contrary curvature are separated in many cases by a straight section. When the latter cannot be made long enough, it is sometimes not used. The two parabolas then come together and are osculatory at the point at which there is no curvature, which then becomes a bend in the layout. We shall see further on that this arrangement has many real advantages from the point of view of the stability of the vehicles when the cant is judiciously adjusted on each side of this transition point.

Other transitions than the parabola of the third degree are used. Thus the *Egyptian State* Railways sometimes use a hyperbola, whilst the *French State* uses, wherever possible, transitions defined by a diagram of versines, the top curve being concave and the bottom convex.

Some railways on which high speeds are not run do not use transitions but are satisfied to draw the circular arcs tangent to the straight section. Experience shows that such layouts are entirely unsuitable for high-speed running.

Many railways have adopted methods of curve adjustment based on the study and correction of the diagrams of versines got out for the curve.

When the ordinates of a constant length chord have been measured at a series of equidistant points along the curve, the corresponding diagram can be studied and corrected, taking into account if necessary any obstacles reported and by calculating the amount the track has to be moved on the pegs on which the layout is based.

In such cases the transitions are usually shown by a diagram of versines represented by a straight line at an angle to the horizontal, which practically corresponds with a cubic parabola.

c) Superelevation on curves.

The superelevation or cant is the difference in level between the two rails, through which the centrifugal force tending to push the vehicles to the outside of the curve is opposed by the component of the weight acting on the plane of the rails.

The superelevation to be given to a curve of radius R run over by a vehicle at a speed V is given theoretically by the formula :

$$h = \frac{e\ V^2}{g\ R}$$

in which e = the distance between the rail centres,

g = the acceleration due to gravity.

In practice V is not the same for all trains or vehicles.

The superelevation therefore can only be calculated for average speeds or for a maximum corresponding to that of the fastest expresses. In the latter case the slower running trains cause abnormal rail wear of the lower rail and a progressive crushing of this rail head.

Then too the theoretical formula gives much too high values of the cant and, in practice, experience has to be relied on either to fix the cant in each case or to

TABLE 15.

Curves : Gauge widening and speed restrictions.

ADMINISTRATIONS.	Gauge widening on curves. (g = gauge, in metres; W = gauge widening, in millimetres; S.L. = straight length; R = radius, in metres).	Rules for speed restrictions in terms of the radius, the superelevation being normal. [V = speed, in km./h.; h = superelevation (cant), in millimetres].
Bulgarian State.	W = 30 — 0.03 R (in metres).	for R = 250, 300, 400, 500, 600 m. V max. = 60, 65, 75, 80, 80 km.
Egyptian State	when R = 500 m. to 400 m. W = 10 mm.; from 400 to 300: 15; from 300 to 200: 20	The speed is limited when the theoretical superelevation exceeds the practical limit of 130 mm.
Northern of Spain	on S. L. and R > 400, g = 1.674 m.; R ≤ 400, g = 1.684 m.	$V = 4\sqrt{R}$
Madrid, Saragossa and Alicante	S. L. and R ≥ 1 000: g = 1.674; 1 000 to 800: 1.676; R = 700: 1.678; 600: 1.680 R = 500: g = 1.682; 400: 1.684; 300: 1.685; 250: 1.686; 200: 1.687	...
Western of Spain	when R = 300: W = 10; 400: 5; ≥ 500: 0	when R < 500: V max. = 60; from 500 to 800: 75; > 800: 85
Alsace-Lorraine	$W = \frac{(1\,000 - R)^2}{30\,000}$; a reduction under consideration.	when R ≥ 700: V max. = 120; from 600 to 700: 110; from 500 to 600: 100; from 400 to 500: 90; from 350 to 400: 80 R from 300 to 350: V max. = 75; from 250 to 300: 65; from 200 to 250: 50
French Est.	R ≥ 500: g = 1.435; from 400 to 500: 1.445; from 200 to 400: 1.455; < 200: 1.445	when R = 500: V max. = 120; 400: 100; 300: 85; 200: 65
French State	On S.L. and R = 800: g = 1.435; from 800 to 500: 1.440; from 500 to 350: 1.445; from 350 to 200: 1.450	R ≥ 600: V. max. = 120; from 600 to 550: 110; from 550 to 500: 100; from 500 to 450: 90; from 450 to 400: 80 R from 400 to 350: V max. 70; from 350 to 300: 60; from 300 to 250: 50
French Nord	On S. L. and R = 800: g = 1.435; from 600 to 800: 1.440; from 450 to 600: 1.450; from 250 to 450: 1.460; < 250: 1.465	Curves with parabolic transitions : R > 500: V. max. = 120; from 450 to 500: 100; from 400 to 450: 90; from 350 to 400: 80; from 300 to 350: 60; from 200 to 300: 40
Paris-Lyon-Méditerranée (P.L.M.)	g minimum = 1.435. when R = 500: g = 1.440; from 250 to 500: 1.450; < 250: 1.460	With the maximum superelevation of 160 mm., the maximum speed is : V = 25 + 0.16 R when R ≤ 333 and V = 45 + 0.1 R when R > 333
P.O.-Midi (France).	when R ≥ 800: g = 1.437; from 400 to 800: 1.450; < 400: 1.460	when R ≥ 700: V max. = 120; from 600 to 700: 110; from 500 to 600: 100; from 400 to 500: 85 R from 300 to 400: 75; from 250 to 300: 60; from 200 to 250: 50; from 150 to 250: 40

ADMINISTRATIONS.	Gauge widening on curves. (g = gauge, in metres; W = gauge widening, in millimetres; S.L. = straight length; R = radius, in metres).	Rules for speed restrictions in terms of the radius, the superelevation being normal. [V = speed, in km./h.; h = superelevation (cant), in millimetres].
Algerian Rys.	when R = from 350 to 500: W = 5; from 250 to 350: 10; from 200 to 250: 15	Standard gauge : V max. = 25 + 0.16 R when R ≤ 333. V = 45 + 0.1 R when R > 333.
Tunisian Rys.	Standard gauge: when R > 350: W = 0; R ≤ 350: W = 10	Standard gauge R = 250: V = 50; 300: 60; 400: 70; 500: 80; 650: 90; ≥ 750: 100
Colonial Railways in French West Africa	R ≥ 500: g = 1.000; from 500 to 400: 1.005; from 400 to 300: 1.010; from 300 to 200: 1.015; from 200 to 150: 1.017	The maximum speed allowed is only 60 km./h.
Portuguese Rys.	R ≥ 1 000: g = 1.665; 800 to 1 000: 1.670; 600 to 800: 1.675; 450 to 600: 1.680; 350 to 450: 1.685; < 350: 1.690	R = 250 300 400 500 600 700 800 900 V max. = 65 70 80 90 98 105 113 120
Mozambique Rys.	R > 1000: W = 0; from 600 to 1.000: 5; from 400 to 600: 10; from 300 to 400: 15; < 300: 20	R > 500: V max. = 80; R < 500: 65
Rumanian State.	R = 300: W = 0; from 250 to 300: 5; from 200 to 250: 10; from 150 to 200: 15	R = 100 120 150 200 250 350 V max. = 20 30 40 50 60 70 R = 500 700 900 1 100 1 300 V = 80 90 100 110 120
Czechoslovak State.	...	R = 150 200 280 350 450 600 700 900 V = 50 60 70 80 90 100 110 120
Turkish State.	R ≥ 400: W = 0; from 400 to 325: 5; from 325 to 275: 10; from 275 to 250: 15	R = 250 300 V = 55 60

Jugoslav State

Present radius.	Present gauge widening.	Proposed radius.	Proposed gauge widening.	Radius	Present maximum speed.	Proposed maximum speed.	Radius	Present maximum speed.	Proposed maximum speed.
metres.	*millim.*	*metres.*	*millim.*	*metres.*	*km./h.*	*km./h.*	*metres.*	*km./h.*	*km./h.*
200/225	25	200/250	27	180	45	45	550	85	90
225/300	20	250/300	24	200	50	50	600	90	95
300/350	17.5	300/350	21	225	55	55	650	90	95
350/400	15	350/380	18	250	60	60	700	95	100
400/500	12.5	380/420	15	300	65	65	800	100	105
500/600	10	420/500	12	350	70	70	900	100	110
600/700	7.5	500/600	9	400	75	75	1 000	100	115
700/800	5	600/700	6	450	80	80	1 100	100	120
800/1 250	2.5	700/750	3	500	85	85			

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get out empirical formulae for calculating the cant in each particular case.

Table 16 gives the different formulæ in use on the railways consulted with the maximum superelevation adopted by each.

It is obvious that the maxima so fixed are decided by the necessity of keeping the inclination of stationary vehicles within reasonable limits so as not to be dangerous nor to upset the passengers.

In practice it is difficult to exceed 18 cm. (7 3/32″). The *French Nord* which has laid certain curves experimentally with 20 cm. (8″) cant, selected places where the trains only stop for exceptional reasons such as sudden failure or breakdown of rolling stock.

A problem similar to that we mentioned for the adjustment of the transitions between curves and tangents arises in connection with the gradients and adaptation to the radii of curves of the various zones of the layout.

In the parabolic transitions, usually cubic parabolas along which the curvature varies linearly, the superelevation should vary in the same way.

This progressive change in the cant forms the superelevation ramp (cant incline) which has to be adjusted each time there is any marked variation in the curvature of the track, especially on entering and running off the curves.

The length of the superelevation ramp L equal to that of the parabolic transition is given in metres by :

$$L = \frac{h}{p},$$

h being the superelevation, in millimetres, of the circular part of the curve, and p the relative slope in millimetres per metre of the two rails.

Table 16 gives the information supplied by the railways in this connection.

It will be seen that the relative slope of the two rails in transitions should be proportionally smaller as the speed is higher. On most of the railways consulted this slope is limited in principle to 1 mm. per m. (1 in 1 000) when the speed is between 100 and 120 km. (62 and 75 miles) an hour. The *Jugoslav State* Railways limit this slope to a maximum of $\frac{1}{6V}$. As a rule the railways are lengthening the parabolic transitions on their main lines. Sometimes the transition curve cannot be made as long as the superelevation ramp and in such cases the latter should begin on the tangent.

A vehicle striking a curve at high speed cannot take up the inclination corresponding to the cant of the curve instantaneously; the superelevation ramp, therefore, should be designed to cause the vehicle to tilt progressively and appreciably about its main axis.

For this reason the required cant should be obtained by lifting progressively the rails which have to be the higher by half the required cant and lowering the other rails the same amount.

By this means a progressive and continuous transition between two reverse curves without intermediate straight length can be obtained successfully when passing from one superelevation to the other without providing a long length with the two rails at the same level, but on the contrary by varying the superelevation uninterruptedly. This method allows the vehicle to rotate continuously in the longitudinal sense without any shock or unpleasant reaction even at very high speeds.

It will be seen in Table 16 that some railways in exceptional cases allow contra-superelevation on curves, as for example in a turnout on a superelevated curve when the turnout is to the opposite direction to that of the main-line. Some railways also give a little superelevation on the straight particularly when approaching a junction so as to give the turnout points some superelevation when the junction has to be run through at speed.

d) **Speed restriction on curves.**

Table 15 is a summary of the general rules in force on the different railways. These rules are sometimes issued as simple formulæ such as V max. $= 4\sqrt{R}$, used by the *Northern of Spain* Railway.

Speed restrictions on curves are generally due to it being impossible to give the road enough cant. Tests of vehicles running through curves at speed have shown, however, that there is no great inconvenience if the cant is not quite sufficient. It has been found possible to run in complete safety and quite comfortably at 100 km. (62 miles) an hour through a curve of 1 000 m. (50 chains) radius without cant.

Some railways allow, in connection with their rules for superelevation, without any speed limitation, an insufficiency of cant to the extent of 20 mm. (13/16″) on the *Czechoslovak* and *Jugoslav* State Railways, and up to 90 mm. (3 9/16″) on the *French Est*. The information received on this subject is given in Table 16.

When the shortage of cant exceeds these amounts, the maximum speed allowed is found by the superelevation formulæ used in which the cant is given its real value increased by the lack of cant allowed or by a special formula as on the *Jugoslav State* Railways.

On the other hand some railways do not allow any lack of cant in principle and deduce the speed at which curves can be taken from the real value of the superelevation *h*.

Still other railways, and this seems the best solution, determine the speed from experience and tests at various speeds. It should be noted that the many tests carried out with this object since the introduction of very fast railcars or motor trains have given more favourable results than with trains hauled by steam or electric locomotives.

Railcars, owing to the relatively low centre of gravity of the body or engines, or their more flexible springing through their lighter weight, are less affected by the track and centrifugal force on curves and especially on the transitions onto and off the curves.

It has been found, in practice, that a railcar or motor train can run some 10 km. (6 miles) an hour faster than an ordinary train through a correctly surveyed and levelled curve.

* * *

CHAPTER III.

Modernising old track for heavy loads and high speeds.

None of the railways consulted possesses track specially laid for carrying heavy vehicles at very high speed. The increase in speed and load, either tried or authorized provisionally or permanently, applies to main-lines the track of which has not been specially strengthened for this purpose.

It is therefore impossible, from previous experience on new constructions, to state exactly how a modern track suited for such traffic should be built. Moreover, none of the railways we consulted is considering the construction or equipment of a new line for this special purpose.

This investigation, therefore, must be limited to an enquiry into the arrangements adopted or proposed to modernise existing track, i. e. to make it suitable for a heavier and faster traffic than that carried up to the present.

The most logical order will be to examine in turn the steps taken to allow the heaviest axle loads to be run, and then to permit of very high speeds.

The first problem has frequently been raised during the development of the main-line railways. The second is relatively new seeing that the speed of

TABLE 16.

Layout of transition curves and determination of the superelevation (cant) on lines run over at high speeds.

ADMINISTRATIONS.	Rules for laying out transition curves : Between a circular curve and a tangent : x = abscissae, y = ordinates relatively to the straight and to the tangent point. L = length of the transition curve.	Between two circular curves : in the same direction.	Between two circular curves : reverse.	Rules used for calculating the superelevation. (h = superelevation in millim., R = radius in metres, V = speed in km./h.).	Maximum cant on the main lines.	Progression and allocation of the superelevation in the transition curves (relative gradient of the two lines of rails = p in mm. per m.	Use of cant on the straight or of negative cant on curves.	Rules governing speed restrictions when the track cannot be given the required cant.
Bulgarian State.	Cubic parabola.	...	Straight section at least 100 m. long.	$h = \frac{12\,V^2}{R}$ for V = 50 km./h.	120 mm.	Linear progression on the length of the transition curve. $p \leqslant 2.5$ mm. per metre.	None.	V given by $h = \frac{12\,V^2}{R}$ h being the possible cant.
Egyptian State	Hallade method or hyperbolic formula.	...	...	$h = \frac{5}{8}$ of theoretical superelevation calculated for V = 90 km./h.	130 mm.	The superelevation ramp is divided as to half in the straight and half in the curve, on a gradient of $p = 2$.	When a branch line is taken off a curve of the same direction the turnout is laid with a general cant.	V is limited when the theoretical cant is > 130 mm.
Northern of Spain . . . . . (5′ 6″ gauge).	Cubic parabola $y = \frac{x^3}{360\,R}$	...	...	$h = 13.66\,\frac{V^2}{R}$ in practice $V = \frac{2}{3}$ max. authorised speed.	160 mm. for R = 250 m.	Linear progression from the origin of the parabolic transition $p < 2$.	None.	V given by $h = 13.66\,\frac{V^2}{R}$ h being the possible cant.
Madrid, Saragossa and Alicante (5′ 6″ gauge).	Usually the transition curves are circular. Parabolic transitions are laid out by means of the versines.	...	...	h varies from 185 to 70 mm. for values of R between 400 m. and 1 000 m.	250 mm. for R ⩽ 300 m.	The superelevation ramp ends at the tangent point of the circular curve; average $p = 1.67$.	When points and crossings are laid on a curve, the cant is reduced and the speed restricted.	The speed is restricted to 40 km. in turnouts with a radius of from 200 to 300 m., and a superelevation of 50 to 40 mm.
Western of Spain	As a rule parabolic transitions are not used. The transitions are laid out approximately by moving back the tangent point on the straight, by deforming the circular curve.	...	...	h varies between 10 mm. for R ⩾ 500 m. and 160 mm. for R = 300 m.	160 mm.	Linear progression $p = 2$.	None.	The speed is limited to 30 km./h. over points with curves of radius smaller than 300 m.
Alsace-Lorraine	Cubic parabola $y = \frac{x^3}{6\,L\,R}$ distributed half on the tangent, and half on the circular curve.	Transition by a series of circular curves.	Straight section at least 50 m. long.	$h = \frac{1\,000\,c}{R}$ c varies between 14 to 85 according to the class of line.	150 mm.	The superelevation ought to be constant throughout the circular curve $p < 2$ on main lines and = 1 if possible.	Cant used on the straight at the approaches of the tan 0.05 junction. Negative cant is only used in the case of points laid on curves when the turnout is in the opposite direction.	Each case specially considered.
French Est.	Cubic parabola $y = \frac{x^3}{6\,L\,R}$ Circular curve moved to the inside by $\frac{L^2}{24\,R}$ (Nordling's formula).	...	...	$h = \frac{12\,v^2}{R}$ with $v = 20 + \frac{2}{3}\,V$ (V = actual speed of fastest train).	150 mm.	Linear progression on the length of the transition curve. p always ⩽ 2 and = 1 in principle.	Cant may be given on the straight approaching a tan 0.05 junction. The turn out of points laid on a curve can be given negative cant if in the opposite direction.	Up to 90 mm. insufficient superelevation is allowed. The authorised speed is found from the formula giving the cant.

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TABLE 16. *(Continued.)*

ADMINISTRATIONS.	Rules for laying out transition curves : Between a circular curve and a tangent : x = abscissae, y = ordinates relatively to the straight and to the tangent point. L = length of the transition curve.	Between two circular curves : in the same direction.	Between two circular curves : reverse.	Rules used for calculating the superelevation. (h = superelevation in millim., R = radius in metres, V = speed in km./h.).	Maximum cant on the main lines.	Progression and allocation of the superelevation in the transition curves (relative gradient of the two lines of rails = p in mm. per m.).	Use of cant on the straight or of negative cant on curves.	Rules governing speed restrictions when the track cannot be given the required cant.
French State	Cubic parabola replaced as far as possible by a curve having a diagram of versines represented by an ellipsoid.	...	...	$h = \frac{1\,000\ c}{R}$ c is a coefficient which varies from 40 to 105 according to the running speeds on the line.	180 mm.	Linear superelevation ramp. p always $\leqslant 1.5$ on main lines and in principle < 1.	As above.	Insufficient cant relatively to the value given by the theoretical formula $h = \frac{11.8\ V^2}{R}$ is allowed as follows : < 100 mm. when $R \leqslant 500$ m. and < 150 mm. when $R > 500$.
French Nord	Cubic parabola $y = \frac{x^3}{6\ L\ R}$ The circular curve being moved to the inside by $\frac{L^2}{24\ R}$ (Nordling's formula).	Cubic parabola. $y = \frac{x^3}{6\ L}\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$	Connected by two cubic parabolas which can be adjacent.	$h = \frac{1\,000\ c}{R}$, c being a constant varying between 20 and 120 according to the running speeds on the line.	usual 180 mm. special 200 mm. for trial.	Linear progression of the superelevation obtained : $\frac{1}{2}$ by lowering the inner line of rails, and $\frac{1}{2}$ by raising the outer line. $p \leqslant 1$ on the main lines if possible, and always $\leqslant 2$.	As above. The cant on the straight may reach 100 mm. Turnouts with negative cant are taken at reduced speed.	The speed is determined by experiments carried out in each particular case.
Paris-Lyon-Méditerranée . . .	Cubic parabola $y = \frac{x^3}{6\ L\ R}$	...	Straight section at least 20 m. long between parabolic transitions unless these are adjacent.	for $V \leqslant 78$ $h = 1\,000\ \frac{V - 25}{R}$ for $V > 78$ $h = 1\,600\ \frac{V - 45}{R}$	160 mm.	Linear progression over the length of the parabolic transition, or if this is not possible using part of the straight section. $p \leqslant 3$ for $V \leqslant 78$. $p \leqslant 2$ or $V > 78$.	As above. Turnouts with negative cant are taken at low speed; the negative cant $\leqslant 40$.	If the lack of cant is slight, the speed is not altered. If great, the speed V is limited to the value given by the formula for the cant.
P.O.-Midi (France).	Cubic parabola $y = \frac{x^3}{6\ L\ R}$	...	...	$h = 1\,000\ \frac{c}{R}$, c varying from 36 to 106 according to the class of the line and the running speeds.	180 mm.	In principle $p = 1$ mm. per m. special cases $p = 2$.	In practice negative cant is only used on turnouts taken at low speed.	Settled in each particular case.
Algerian Rys.	Parabolic transition.	Parabola.	Parabola.	Standard gauge lines : for $V \leqslant 78$ $h = 1\,000\ \frac{V - 25}{R}$ for $V > 78$ $h = 1\,600\ \frac{V - 45}{R}$ Metre gauge lines : $h = 730\ \frac{V - 25}{R}$	160 mm.	Linear progression on the length of the transition. $p \leqslant 3$ for $R \leqslant 330$ m. $p \leqslant 2$ for $R > 330$ m.	None.	This case does not arise.
Tunisian Rys.	Hallade or Cambier transition or simply a circle tangent to the straight section.	...	At least one rail length on the straight without cant.	Standard gauge lines : $h = \frac{11.8\ V^2}{R}$ Metre gauge lines : $h = \frac{8.2\ V^2}{R}$	150 mm. 100 mm.	Linear progression on the length of the parabolic transition — or all on the straight section in the case of a circle tangent to it. $p \leqslant 2$	None.	Speed limited by the formula giving the cant.

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TABLE 16. *(Continued.)*

ADMINISTRATIONS.	Rules for laying out transition curves : Between a circular curve and a tangent : x = abscissae, y = ordinates relatively to the straight and to the tangent point, L. = length of the transition curve.	Between two circular curves : in the same direction.	Between two circular curves : reverse.	Rules used for calculating the superelevation. (h = superelevation in millim., R = radius in metres, V = speed in km./h.).	Maximum cant on the main lines.	Progression and allocation of the superelevation in the transition curves (relative gradient of the two lines of rails = p in mm. per m.).	Use of cant on the straight or of negative cant on curves.	Rules governing speed restrictions when the track cannot be given the required cant.
Colonial Railways in French West Africa (Metre gauge).	Circular curve tangent to the straight section.	...	...	$h = \frac{15\,000}{R}$	50 mm.	Linear progression half on the straight and half on the circular curve. $p = 2$.	None.	This case has not arisen.
Portuguese Rys. (5′ 6″ gauge).	Cubic parabola Cambier formula $y = \frac{x^3}{6\ L\ R'}$ $R' = 0.951\ R$.	Connected by a circular curve.	Always separated by a straight section.	$h = \frac{1\,000\ V}{R}$ with V = 90 varying with the gradient section of the line.	200 mm.	Linear progression on the length of the parabolic transition — one line of rails lowered and one raised, p varies between 1 and 3.	None.	If the lack of cant is slight V is not altered. If considerable, V is restricted in accordance with the cant formula.
Mozambique Rys.	Cubic parabola $y = \frac{x^3}{6\ C}$	...	...	$h = 7.9\ \frac{G\ V^2}{R}$	115 mm.	Linear progression over the length of the transition.	None.	...
Rumanian State.	Cubic parabola half on the tangent and half on the circular curve. L = 80 m. for R from 300 to 500; 60 m. from 500 to 1 500; 40 m. from 1 500 to 3 000	...	Straight section at least 30 m. long.	$h = \frac{500\ V}{R}$ V = maximum allowed speed.	120 mm.	Linear progression over the length of the transition.	None.	The speed is reduced as dictated by experience.
Czechoslovak State.	Cubic parabola $y = \frac{x^3}{6\ L\ R}$ when $\frac{L^2}{6\ R}\left(\frac{1}{\cos\lambda} - 1\right) < 10$ mm. $y = \frac{x^3}{6\ L\ R \cos\lambda}$ when $\frac{L^2}{6\ R}\left(\frac{1}{\cos\lambda} - 1\right) \geqslant 10$ mm. λ being given by $\sin.\ \lambda = \frac{L}{2\ R}$	Cubic parabola osculatory to the two circles.	The parabolic transitions are separated by at least 50 m. of straight for V ⩽ 110 km./h. and of 100 m. for V > 110 km./h. If impossible they are adjacent.	$h = \frac{8\ V^2}{R}$ V = actual speed.	150 mm.	Linear progression over the length of the transition. $p = 1.67$ for $60 < V < 80$; $p = 1.33$ for $80 < V < 95$; $p = 1$ for $V \geqslant 100$.	None.	Lack of cant up to 20 mm. is allowed without any speed restriction; beyond the speed is restricted according to the cant formula.
Turkish State.	Transition laid out by abscissae and ordinates.	...	...	$h = \frac{600\ V}{R}$	132 mm.	Linear progression over the length of the transition. $p = 2.5$ mm. p. m.	None.	The speed is restricted.
Jugoslav State	Cubic parabola $y = \frac{x^3}{6\ C}$	...	...	$h = \frac{8\ V^2}{2}$	120 mm.	Linear progression over the length of the transition. $p = 3.33$ V ⩽ 40; $= 2.5$ 40 < V ⩽ 50; $= 2$ 50 < V ⩽ 60; $= 1.67$ 60 < V ⩽ 80; $= 1.33$ 80 < V ⩽ 95; $= 1$ V > 95; p always ⩽ $\frac{1}{6\ V}$	None.	Lack of cant up to 20 mm. is allowed. Above this the speed is limited to V max. = $\sqrt{(2.5 + 0.125\ h)\ R}$

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120 km. (75 miles) an hour was the maximum worked to by some railways for more than half a century.

The second problem in most cases is obviously connected with the first. It arises, however, quite independently in some cases, such as when it is necessary to work on secondary lines where the track is relatively old, light trains or single vehicles such as railcars with a light axle load, which the existing track can carry without any difficulty.

Equipment of the track to carry very heavy loads.

The steps taken obviously depend upon the nature and conditions of the present equipment of the track.

The first element which carries the axle load directly is the rail.

The increasing axle loads have for the last fifty years caused most railways to increase the section and weight of the rails in order to reduce the number of broken and damaged rails as well as the crushing of the rail head.

The rails now generally used on the main-lines weigh 45 to 50 kgr./m. (90.7 to 100.8 lb. per yard), and have gradually replaced the lighter rails weighing about 30 kgr. (60.5 lb. per yard) formerly used on most railways.

When this change was undertaken the heaviest axle loads were about 15 tons and were only found on the most powerful and fast locomotives. We saw in Chapter I that the axle loads on many high-capacity goods wagons as well as locomotives now exceed 20 tons. There seems to be a movement towards a practical axle load of 22 tons.

The undoubted increase in stresses on the track resulting from this fact, its effect on the general behaviour of the track and the frequency of maintenance work, such as renewal of rails, leads us to think that the resistance of the present rails must be very close to their limit as regards the stresses they should stand up to.

We saw that the *P. L. M.* Railways adopted some three years ago on their more important main-lines an exceptionally heavy rail, which weighed slightly over 62 kgr./m. (125 lb. per yard). The results obtained do not yet allow any definite opinion to be expressed as to their value. No other railway has reported any intention of following this example, and using definitely heavier rails than at present.

It appears that we have now arrived at a stage in the evolution of the permanent-way equipment much like that at which the rail section was appreciably increased about fifty years ago.

This step would certainly be opportune, if on the one hand it enabled the rail to better stand up to shocks and fatigue, especially if this were the result of improved methods of working up the metal and rolling the rails.

This, therefore, is the problem actually set to both the manufacturers of rails and permanent-way engineers.

It should be added that the adoption of a heavier rail, of well designed section, and carefully manufactured, would doubtless make it easier to introduce high speeds while maintaining the layout and level of the track more perfect and durable and reducing as much as possible maintenance work and expenditure thereon.

It should also be recalled that, as has been stated above, the fishing of the rails is not yet entirely satisfactory as regards the track standing up properly. Experiments and investigations have resulted in various devices which have to be very carefully maintained at frequent intervals if they are to be satisfactory.

As regards the sleepers, the increase in the number per unit length is, it would appear, one of the best methods by which the track can be made suitable for carrying heavy loads more easily. A greater number of sleepers reduces the stress

on the rails, by supporting them at a greater number of points, and thereby distributing more uniformly the load carried by the track and transmitted to the formation through the ballast.

Our opinion is that one of the first measures to be taken in order to deal with heavy loads is to increase the sleepering. This strengthening is only limited by the need for levelling the track suitably, whatever the space between the sleepers, whether by shovel packing, tamping, or any other suitable process.

The question of a suitable arrangement of the rail fastenings is very important with heavy axle loads. These tend, especially at low speeds through curves, to increase the load on the lower file of rails, i. e. that with the smaller radius, to drive the foot of the rail into the sleepers when they are wooden ones, or to deform them when steel sleepers are used. This drawback is only avoidable by a suitable method of securing the rails to the sleepers, getting sufficiently good contact between the sleeper and the foot of the rail, and preventing the latter from destroying the sleeper by excessive pressure or repeated vertical shocks.

We have seen that, in order to overcome these drawbacks elastic packings of the same width as the rail foot, with metal bearing plates larger than the rail foot, are placed between the rail and the bearing surface of the sleeper.

The effect of the former is to absorb shocks occurring when each axle passes by introducing immediately under the rail a flexible and yielding element; the second increases the bearing surface and contact surface with the sleeper.

A properly designed bearing plate should satisfy the three following conditions :

— reduce the unit pressure of the rail on the sleeper;

— prevent the horizontal movement of the rail under the side loads to which it is subjected;

— hinder the tendency of the rails to turn over under the same forces, which bend and gradually pull out the coach screws securing the rails directly to the sleeper.

The first point is quite easily met by making the bearing plate large enough.

The second can be met if the bearing plate is rigidly and solidly fastened to the sleeper in such a way as to prevent movement, and by holding the rail on the bearing plate in grooves, clips, etc.... to prevent it moving sideways.

The tilting of the rail and consequent pulling out of the coach screws can only be avoided by fastening the rails onto the bearing plates rigidly by a fastening independent from that holding the bearing plates to the sleeper.

Rail fastenings based on these points can obviously be designed in different ways. It appears that rail fastenings designed on these principles have given the best results under the increasing stresses to which they are subjected, and that they can most easily be maintained in good order.

In order that the loads may be suitably distributed, the thickness and width of the layer of ballast should be increased to give the track more elasticity and above all a larger bearing surface on the formation.

If in practice it is found that the ground is not able to carry the vertical loads of very heavy axle loads, a layer of small material such as fine sand, etc.. should be laid between the roadbed and the ballast to improve load distribution.

As regards the structures, which are the most important part of the formation, their strengthening or possible renewal depends upon the circumstances under which they were built, and their condition according to rules with which we shall deal later on.

Modernising the track for high speeds.

If the track has to carry heavy locomotives or rolling stock worked at high speeds, the various measures just dealt with will have to be applied before the speed can be really increased over the lines concerned.

Running at high speeds, however, raises other problems.

Indeed, a vehicle or train can only run at very high speed over a given section of line if the curves allow it.

We saw in the previous chapter the precautions to be taken to guide the vehicle at high speed and deflect it from the straight line it tends to follow by tilting it progressively towards the interior of the curve to the extent necessary to balance the centrifugal force.

The modernisation of the present track to render it suitable for high speeds involves first of all a careful examination and revision of the layout and level of the curves. The track should be capable of carrying high-speed traffic without danger to the track or vehicles or discomfort for the passengers.

The superelevation should not be increased unreasonably. We saw that the maximum of 18 cm. (7″) is not current practice except on a few railways, and could hardly be taken as satisfactory if the trains had to stop on the section of line in question.

Running at very high speeds, therefore, raises the problem of what is, in terms of the radius, the maximum possible speed on a curve where the maximum superelevation can be provided.

Taking into account the tests carried out and experience acquired in this connection, it appears that the following figures are the maxima it is difficult to exceed :

A curve of 800 m. (40 chains) radius will not allow of speeds above 140 km. (87 miles) an hour;

A curve of 700 m. (35 chains) radius will not allow of speeds above 130 km. (81 miles) an hour;

A curve of 500 m. (25 chains) radius will not allow of speeds above 120 km. (75 miles) an hour.

It should be noted that these are real maxima which cannot always be reached as has been shown by the tests made at the present time on the different railways concerned. In addition, these figures suppose implicitely that the location of the curve, especially the transitions onto and off it, have been perfectly adjusted and that the difference in level of the two rails has been minutely checked to make the variations in superelevation at each end really gradual.

Modernising existing track for very high speeds is only possible if its layout does not include curves of a radius smaller than the figures given above, taking into account the speed to be attained. It is also desirable to recognise the possibility of making the curves on a particular section with a very closely studied location, carefully corrected, to include :

— circular parts on which the superelevation is sufficient to equalise the centrifugal force developed when passing over the curve, taking into account the experience acquired for trains and isolated vehicles such as railcars;

— transitions of sufficient length onto and off each circular part progressively and in such a way that the superelevation is gradually attained, if possible by variations near 1 mm. per m. (1 in 1 000) and in any case not exceeding 2 mm. per m. (1 in 500).

These conditions are essential, though it has been found that on well sprung rail motor cars or motor trains of uniform design, if there is insufficient superelevation on a circular section, the only effect is to force the flanges of the outer wheels on to the corresponding rail and to remove all shock if the track is properly laid out, with a tendency to

throw the passengers over towards the outside under centrifugal force. But such conditions are not only uncomfortable, but also gradually deform the track under the effect of the repeated lateral thrusts and give rise to shocks the consequences of which can be serious and possibly be the cause of accidents. They can consequently be prohibited except for light vehicles of great flexibility, with a relatively low centre of gravity, as such vehicles react only slightly on the track.

The same effects can moreover arise when the alignment and levelling of the track have not been properly adjusted so that the vehicles are given shocks the violence of which rapidly increases with the speed.

It is therefore essential to maintain very carefully the whole of the track which will be run over at high speed, after having, by a thorough study of the section concerned, considered the possibility of correcting and suitably levelling the curves and particular points in the track, such as junctions or zones in which there are points and crossings, bridges, level crossings, etc., and deciding by a series of tests the maximum speed which can be worked to.

Partial or complete overhaul intervals should be shortened and the tolerances allowed in carrying out maintenance work be revised. All methods or processes which help to improve the quality of the levelling work, aligning each line of rails, and improving the stability of the track make it easier to operate railways at high speeds.

It is desirable to recall, in this connection, that the vertical shocks produced by defects in the level of the rails, however small, inevitably cause lateral reactions, i. e. side thrusts of the wheel flanges on to the rails, which in turn soon increase the defects which caused them. This is why high speeds require the maintenance of a very accurate level of the two lines of rails, and in practice the railways are led to reduce progressively the allowable tolerances in order not to exceed practical limits which frequently range about a few millimetres.

It is therefore very desirable to find satisfactory solutions by which the number of joints can be reduced, the presence of which, particularly the width of which, helps to break up the track by inevitable shocks. In practice the increasingly high speeds now practised make a permanent way free from restrictions and causes of deterioration due to the presence of joints much to be desired.

The maintenance of a perfectly correct laying and the strength of the track to the reactions and lateral thrusts of the vehicles obviously profit by the increased rigidity due to strengthening the superstructure : increasing the section and weight of rails, increasing the number of sleepers, improving the fastenings, etc... This rigidity can be still further increased by suitable devices such as those previously described.

We pointed out at the beginning of the previous chapter that steps must be taken to allow single vehicles of low weight or rakes of relatively light and closely coupled units to run at high speeds on secondary lines with a relatively old track.

Obviously in such a case the weight of the vehicles does not require the track to be strengthened, the essential being to obtain suitable running conditions and sufficient resistance for their lateral guiding. In this case it is desirable to

— make and maintain the track correctly aligned and levelled so as to avoid shocks in running;

— reinforce the lateral stability of the track by increasing the number of sleepers, improving the fastenings, or by the processes already described, tested or used by certain railways.

Naturally measures which can give light track sufficient rigidity to allow o

high speeds for light vehicles cannot in any way be considered sufficient to authorise under the same conditions the circulation of heavy locomotives or trains.

We consider that for such traffic the track should above all, thanks to the weight and intimate connection between all the materials which make it up, retain its proper stability under the vehicles running over it. It is therefore by being well equipped, properly aligned, and carefully levelled, that a light track will be made fit to carry heavy and very fast traffic.

* * *

PART TWO.

Facing points which can be taken at high speeds.

High commercial (overall) speeds are only possible when they can be maintained without interruption over long distances, i. e. without having to slow down at junctions and on entering or leaving stations, etc.

Speed restrictions of this kind are usually due to the presence of points and crossings which cannot be taken at high speed on account of their design, construction, or level.

Generally speaking, there is no particular difficulty in running through points when in the position corresponding to the through track. Practically no railway imposes any speed restriction on running through trailing points.

When the points are taken facing, the speed is sometimes limited for questions of principle, signalling or safety, without there being any question of the comfort or stability of the vehicle since the vehicle follows the through straight line.

Actually many railways allow trains to pass over points at the maximum speed allowed on open track, and this practice so far has not shown any drawbacks.

The position is quite different when the vehicle runs onto the branch line, i. e. the curved track leading from the through road.

In this case, whether the points be taken facing or trailing, the vehicle has to run round the turnout curve and is sometimes acted upon by the check rail which protects the gap in the crossing. If the vehicle is to follow the curve progressively without shock it is necessary, therefore, for the points and crossings to be very carefully designed and built.

From the replies received, it appears that only the *Rumanian State, Jugoslav State* and the *French main-line Railways* use points designed to be taken at high speed.

The *Czechoslovak State* Railways which limit the speed to 30 km. (18.6 miles) an hour when running into a junction, are designing a type of point which can be taken at speed.

The *Egyptian State* Railways use crossings on which the tangent of the angle of crossing is 0.10, and the *Portuguese Railways* 0.09 and 0.11, a maximum speed of 30 km. (18.6 miles) an hour being authorized over these crossings.

We have summarised below the replies of eight railways who use turnouts run over at high speeds.

* * *

CHAPTER I.

Layout.

The essential elements in the layout of points and crossings are the angle of tongue with stock rail, the angle of crossing, the curves of various radii and the straight sections met on the branch line, and finally the gauge of the track in the different parts of the appliance.

The replies we received on this subject are summarised in Table 17 hereafter.

TABLE

Characteristics of the layout of points which c

ADMINISTRATIONS.		Angle of tongue with stock rail.	Angle of crossing.	Layout of the branch line. (SS = straight section; R = radius of curve)		
				from the point of the blade to the heel.	from the heel of the blade to the crossing.	in the crossin
Alsace-Lorraine		20′	2° 51′ 44″ 66 tan : 0.05	R = 1 000 m.	R = 1 000 m. up to 4.085 m. from the mathematical point.	S S
French Est	simple points	30′	tan : 0.05	R = 2 000 m. up to the separation of the rail heads.	R = 1 300 m.	R = 1 300
	symmetrical double points.	15′	tan : 0.05	R = 4 000 m. up to the separation of the rail heads.	R = 2 600 m.	R = 2 600
French State		30′	3° 26′ 17″ 74 tan : 0.06	R = 900 m. and 2 000 m.	R = 900 m.	R = 900
French Nord	simple points	45′	tan : 0.05	Cubic parabola of radius varying from ∞ up to 810 m.		R = 1 300
			tan : 0.06	S S on 4 m. then R = 736 m.	R = 736 m.	S S
		51′ 34″	tan : 0.07	S S on 4 m. then R = 736 m.	R = 502 m.	S S
	symmetrical double points.	25′ 47″	tan : 0.06	S S	R = 1 329 m.	S S
			tan : 0.07	S S	R = 945 m.	S S
Paris-Lyon-Méditerranée		51′ 33″ 74	tan : 0.06	S S on 4.40 m. then R = 750 m.	R = 750 m.	S S
		This company also uses the Est type of tan : 0.05 points and crossings.				
P.O.-Midi (France).		35′	4° 0′ 33″ tan : 0.07	R = 550 m.	R = 550 m.	S S
Rumanian State.		24′ 58″ 6	4° 5′ 8″ tan : $\frac{1}{14} = 0.07143$	R = 500 m.	R = 500 m.	S S
Jugoslav State		27′	tan : $\frac{1}{14} = 0.07143$	R = 500 m.	R = 500 m.	S S

run over on to the branch line at high speeds.

Gauge of the track								
: the end the stock ils on the le of the blades.	In line with the point of blade.		In line with the heel.		Between the blades and the crossing.		In the crossing.	
	in the through road.	in the branch.	in the through road.	in the branch.	in the through road.	in the branch.	in the through road.	in the branch.
1.435 m.	1.44 m.	1.44 m.	1.435 m.	1.435 m.	1.435 m.	1.435 m.	1.435 m.	1.435 m.
———	1.445 m. over the whole length of the points and crossing. ——→							
———	1.445 m. over the whole length of the points and crossing. ——→							
———	at present : 1.445 m. — proposed : 1.435 m. over the whole length of the points and crossing. ——→							
———	1.435 m. over the whole length of the points and crossing. ——→							
———	1.445 m. over the whole length of the points and crossing. ——→							
———	1.444 m. over the whole length of the points and crossing. ——→							
———	1.440 m. over the whole length of the points and crossing. ——→							
.435 m.	1.435 m.	1.435 m.	1.435 m.	1.450 m.	1.435 m.	1.450 m.	1.435 m.	1.435 m.
.439 m.	1.445 m.	1.445 m.	1.435 m.	1.447 m.	1.435 m.	1.447 m.	1.435 m.	1.435 m.

In points, the reduction of the angle of tongue with stock rail has not exceeded 20 min., a figure used by the *Alsace-Lorraine* Railways alone.

There is nothing to show that this factor is as important as the layout of the whole of the points from the blade to the crossing. So that the radius of curvature of this part of the points should be as large as possible, the length of the zone separating the points from the crossing must be increased and the value of the angle of crossing reduced as much as possible.

The smallest angles of crossing that we have had reported were 2° 51′ 44″ 66, which corresponds to a tangent of 0.05.

The greatest radii of the curves corresponding to the layout of the points are those of the crossing used on the *French Est* Railway with a tangent of 0.05, the radius being 1 300 m. (65 chains) in the ordinary turnoff.

The *French Nord* is testing a crossing with a tangent of 0.05 in which the turnoff includes a parabolic transition starting from the point of the blade so that the angle of divergence of the crossing can be taken progressively.

With this arrangement, which appears to be rational, as there is no reason for treating differently the curves of the running road and those of the points to be run over at the same speed, the only discontinuity left in the layout of the transition of the through track with the turnout will be the angle of tongue with stock rail, and it will thus be possible to appreciate the influence of the latter in points and crossings of this kind.

The gauge of the track is usually wider in points and crossings especially on the turnout. Most railways are reducing this gauge in order to improve the guiding of the wheels; for example the *Alsace-Lorraine* is building points and crossings the gauge of which is constant over the whole length, and equals 1.435 m. (3′ 3 3/8″), except in line with the point of the blade where it is 1.440 m. (4′ 8 23-32″).

It seems furthermore possible to design points without widening of the gauge on the whole of the straight line, and this design will be tested by the *French Nord* in its new points and crossings with 0.05 tangent.

* * *

CHAPTER II

Points and crossings.

The points giving access to two directions consists of two main parts, the points and the crossing, connected by rails. They include a certain number of additional details, such as rail fastenings, operating gear, safety devices, etc...

Points.

The pair of points is the part of the switch which guides the flanges of the wheels in the desired direction when they run onto the point of the blade. It is in fact the part which plays the vital part during the passage of vehicles.

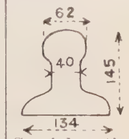
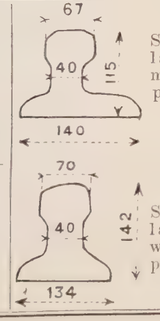
The data we received on points designed for high-speed running are summarised in Table 18.

The metal used for the points and stock rails is of no particular interest, and is heat-treated only on the *French Est* Railway.

The bars from which the stock rails are machined are generally of the usual section. Those from which the blades are machined are usually of special section with a thick web and strengthened foot. This section is not symmetrical and its height is less than that of the ordinary running-track rail on the *Alsace-Lorraine* and on switches laid on metal sleepers on the *Jugoslav State* Railways. The heel of the special section blades is usually machined so that it can join up with rails of standard sec-

TABLE 18.

Design of points and crossings taken at high speeds.

ADMINISTRATIONS.	Points								Crossings		
	Kind of sleepers and fastenings.	Quality of metal used in the points and crossings.	Rail section from which are planed		Angle of the machined faces of the blade to the vertical.		Type of blade : flexible or articulated.	Length of the blades.	Monoblock type or built up from rails.	Nature of metal of monoblock points.	Length of the crossing.
			the blades.	the stock rails.	Inside of the track	Stock rail side					
Alsace-Lorraine	Wood sleepers — metal bearing plates coach-screwed to the sleepers — rails fastened to the bearing plates by bolts and clips.	65-kgr./mm² Thomas steel not heat-treated.	Section as sketch, the full length except at the heel where the section of the blade merges into the S. 39 section.	Standard sections 55-kgr./m. S. 39 or 46-kgr./m. S. 33.	1/5	1/3.7	Flexible.	14 m.	Monoblock nose assembled by bolts and cross-stay keys with wing rails of 55-kgr./m. per S. 39 rails : the whole fastened by bolts and clips on a bearing plate coach-screwed to the sleepers.	Ni. Cr. cast steel.	Monoblock nose : 3.8425 m. long; length of whole crossing : 5.4725 m.
French Est	Wood sleepers and coach-screws.	The same metal as used in the running lines : it is heat-treated.	Standard 55-kgr./m. S. 39 or S. 11 section.		1/4	2/5	Flexible.	14 m.	Monoblock.	Cast Mn. steel.	8.20 m.
French State	Wood sleepers and coach-screws.	70-kgr./mm2 steel not heat-treated.	Standard 55-kgr./m. S. 39 section		1/4	2/5	Flexible.	14 m.	Monoblock.	Cast Mn. steel.	8 m.
French Nord	Wood sleepers and coach-screws.	80-kgr./mm² Thomas steel not heat-treated.	 Section as sketch except at heel where it merges with section of 46-kgr./m. S. 33 rail. Special section with web at 1 in 20 and foot reduced to 102 mm.	Standard 46-kgr./m. S.12 section.	1/4	1/6	Flexible.	12 m.	Monoblock.	Cast Mn. steel.	8.20 m. (tan 0.05)
				Special section with web inclined 1 in 20 and foot reduced to 102 mm.	1/5	1/20	Flexible.	12 m.	Monoblock.	12 % manganese steel. T.S. = 90-kgr. per mm². E = 40 %.	8.00 m. (tan 0.06) 6.65 m. (tan 0.07)
Paris-Lyon-Méditerranée	Wood sleepers, chairs and coach-screws.	80-kgr./mm² steel not heat-treated.	Ordinary rail section.		1/5	1/20	Usually articulated and not flexible.	Variable.	Usually monoblock on the main lines.	Mn. or Ni. Cr. Cast steel.	9.185 m. (tan 0.06)
P.O.-Midi (France)	Impregnated oak sleepers and coach-screws.	Ordinary rail steel not heat-treated.	Same section as in the tan 0.05 46 kgr./m. points of the French Nord (sketch above).	Standard 45-kgr./m. S. 33 section.	1/4	1/5	Flexible.	9.35 m.	Monoblock.	Cast Mn. steel.	4.14 m.
Rumanian State	Oak sleepers and coach-screws.	72-kgr./mm2 Martin steel not heat-treated.	Special section.	Ordinary rail section.	...	1/3	Articulated.	8.50 m.	Monoblock.	Forged steel heat-treated T.S. = 90-kgr. per mm².	...
Jugoslav State	Metal sleepers with bolts and clips or wood sleepers with bearing plates and coach-screws.	80-kgr./mm² Siemens-Martin steel with heat-treatment if called for.	 Section for laying on metal sleepers. Section for laying on wood sleepers.	Section of ordinary line 45 kgr./m. S. 45*a* rails.	1/4	2/5	Flexible.	11 m. when laid on metal sleepers.	Nose of assembled rails on metal sleepers.	Cast Mn. steel with 12 % of manganese. T.S. = 90-kgr. per mm². E = 40 %.	When crossing assembled 8.074 m.
								9 m. wood sleepers.	Monoblock on wood sleepers.		Monoblock 3.44 m.

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ion to which it is connected by ordiary fish-plates.

The *Alsace-Lorraine* and *Jugoslav tate* Railways lay the stock rails vertilly, like the *French Nord* in its latest esigns. The *French Est, State, P. L. M., .O.-Midi* Railways use special chairs hich give the stock rail a slope of 1 in) to the vertical. In both cases the lades are laid vertically. The *French ord* for a long time used a different ethod which consisted in machining ie point blades and the stock rails from ils of special section, the web of which inclined 1 in 20.

Nearly all the points for high-speed nning are built with flexible blades id supported heels. The greatest ngths are some 15 m. (49′ 2 1/2″). The exibility of the thick blades is generally btained by reducing the thickness of ie web and cutting the foot near the eel. The blades are planed with a slope the vertical of 1/4 or 1/5 on the side of the track, but this is very ariable on the stock rail side. All the ilways plane the rails in this way in der to reduce the height of the blade adually and to introduce between the ue point of the blade and the running rface of the stock rail a difference of vel varying, according to the railway, om 12 to 24 mm. (15/32″ to 15/16″).

The *Jugoslav State* Railways are the ly ones to use metal sleepers on acount of the ease and accuracy with hich the line can be laid. They give ie track great lateral stability which pposes particularly well the thrusts or nocks vehicles exert on the large radius the turnout.

To improve the life of points and ossings carried on wood sleepers, the *lsace-Lorraine* Railways fasten under ch sleeper angle irons parallel to the ntre line of the track; the vertical wing these angles digs into the ballast and nchors the track.

The under face of the blades slide on steel chairs secured to the sleepers like bearing plates, and sometimes connected by steel plates carried on the sleepers.

In most cases the stock rails are connected to the point chairs by bolts through both the web of the stock rail and a shoulder of the point chair. Switches with blades of reduced height made by the *Alsace-Lorraine* and *Jugoslav State* Railways include a fastening of the stock rail quite different in design, which seems to be very rigid. On the outside of the track, the stock rail is supported by wedges and its foot is carried on a bearing plate held down by bolts and clips; on the inside it is held in place by the slide plates of the points which are riveted to the bearing plate, and sometimes held by a separate series of bolts and clips.

The *French Nord* uses on an ever increasing scale particularly rigid points in which each of the two stock rails is welded electrically on its foot to a longitudinal steel plate. This plate is cut away so that it acts on each sleeper as a slide plate for the blade. This arrangement was tried at first in sidings, but is now progressively extended to worn running track in a measure as welding processes are improving and as the strength and long life of such equipment is being confirmed.

Crossings.

The crossing, as its name indicates, is the part which permits of the wheel running on one file of rails passing onto the other at the point the two directions are no longer overlapping and diverge. A gap in the rolling surface has to be allowed for the flanges to clear, this gap being protected by the check rails which guide the wheels and prevent the flange dropping into the gap and striking the nose of the crossing.

The angle of crossing is that between the two files of rails immediately clear of the crossing point.

As the point of the crossing is heavily stressed, the type most commonly used is the monoblock in cast manganese or nickel-chrome steel, with a high breaking strength and good elongation. This type has no bolts to tighten up and is practically undeformable; consequently it is easy and cheap to maintain.

However, these parts are relatively costly so that any serious local wear or defect, especially cracks at changes of section through excessive bending under load, involves their renewal. It is therefore necessary to maintain the correct level of such monoblock points very carefully. Consequently it is desirable that the manufacture of this special equipment should be made as nearly perfect as possible. The methods resorted to for repairing and restoring worn or damaged points, as well as those used for fabricating rigid and practically indeformable points and crossings by welding should be perfected and their use extended.

In our view, the most important thing is to prevent the crossing yielding under passing wheels, and therefore it should be made as rigid as possible. Wear, especially the progressive slacking of the parts of the crossing can only be prevented by fitting the parts strongly together.

The *Alsace-Lorraine* and *Jugoslav State* Railways, amongst others, still use built-up points, the nose itself being a monoblock steel casting in some cases.

The lead of crossings is as long as 8.20 m. (26′ 11″) on the 0.05 crossings on the *French Est* and 9.185 m. (30′ 1 7/16″) on the P.L.M.

The points of the monoblock crossings are fastened to the sleepers with ordinary coach screws. The *Alsace-Lorraine* Railways fasten down its built-up points in the same way as other parts; the nose of the crossing and the wing rails are bolted and clamped down to a general bearing plate which is fastened to the sleepers by coach screws.

The wheels are guided through the crossing by check rails of different designs and arranged in different ways according to the railway. The *Alsace-Lorraine* Railways use an angle check rail the top being 27 mm. (1 1/16″) above the rails, the check rails being fastened to them by bolts and ties. In addition the rail and its check rail are fastened to joint sole plates by bolts and clips.

None of the railways report the use of mobile wing rails.

The rails between the points and the crossings are of the same section as the ordinary rails.

According to the replies to the question on this subject, all the railways provide joints to allow expansion between the points, the connecting rails and the crossing. The gap in these joints is calculated like for the running track, according to the length of the rails and the temperature. Only the *Alsace-Lorraine* Railways have eliminated the expansion joints between the connecting rails and the crossing.

It seems that, owing to their rigidity, points and crossings ought to be considered as a unit, the variations of length under temperature changes being transferred to each end.

If the points, connecting rails, and crossing are all close together, there need be no breaks in the rolling surface, which means no shocks from the wheels passing over the gaps.

We therefore asked the railways if they welded the different parts of the crossing together.

From the replies received it appears that no railway has done this, either owing to the difficulty of welding ordinary rails to the parts in special steel such as manganese steel noses, or for fear of complication when renewing worn or damaged parts.

However, a number of railways, for example the *Egyptian State, Alsace-Lorraine, French Nord* and *Portuguese*, a

velding on a more or less wide scale he rails or chairs to plates. Up to the resent, this method is only being tried xperimentally on the main lines. As as been stated it is frequently used in idings, at least on the *Alsace-Lorraine*, nd *French Nord* Railways. On the lat- er, more than 1 200 parts of points and rossings have been welded to plates nd have been entirely satisfactory. The nethod is a great advance and is rela- ively cheaper than when bolts are used s the life is greater and the mainte- ance costs less. The first cost is also nuch less than monoblock castings.

Another interesting application of velding is in use on a large scale on the *rench Nord* and to some extent on ther railways, namely building up the vorn or crushed running surface of the pecial parts of switches : points cros- ing, connecting rails, etc. by electric velding. By restoring the section in his way costly and frequent renewals re avoided.

The connecting rails are fastened to he sleepers in the same way as on the unning track. The fastenings consists f coach screws or bolts and clips and ometimes includes packings and bear- ng plates between the rail and the slee- er. The *Alsace-Lorraine* uses ribbed netal plates with a heel and double in- lependent fastenings.

The fishing of the connecting rails ogether and to the other parts of the oints and crossings is with fishplates f the same kind as on the running rack. Special fish-plates are only used o connect rails or special parts of dif- erent sections.

The manufacturing and erecting tole- ances are the usual ones with the ex- eption of the *French Est* on which the oles in the fish-plates, in the blades nd stock rails are 28 mm. (1 7/64″) in diameter, whereas elsewhere they are 32 mm. (1 17/64″).

All the railways using points and crossings for fast running use chairs, ties, rail braces, and distance blocks in cast steel and do not allow any cast iron parts to be used.

* * *

CHAPTER III.

Conditions under which points and crossings are laid and run over.

Table 19 gives the lengths of the crossings built for high-speed running. Some of the longest reported are the tangent 0.05 crossings of the *French Est* and the P.L.M. where the total length is 58 m. (190′ 3 1/2″) and those recently laid on the *French Nord*, which are 62.681 m. (205′ 7 9/16″).

The length of the tangent 0.06 turnouts varies from 45.70 m. to 54 m. (149′ 11 1/4″ to 177′ 2″); and those of the 0.07 turnouts between 40 m. and 45 m. (131′ 2 3/4″ and 147′ 7 3/4″).

The *Rumanian* and *Jugoslav* State Railways never lay points and crossings with superelevation, nor on curves run over at high speeds.

All the *French main-line Railways* report that they allow points and crossings being laid on curves, and with the exception of the P.L.M. give them a slight superelevation.

However, the *Alsace-Lorraine Railways* do not insert on curves points to be taken at speed. To make it easier to take points at 100 km. (62 miles) an hour, they sometimes give a slight general superelevation of about 20 mm. (25/32″).

The *French Est* only lays tangent 0.05 points on curves of 4 000-m. (200 chains) or larger radius, provided that the turnout is towards the inside of the curve and the points are then laid with no, or very little, superelevation.

The other *French* railways impose no particular restrictions in laying points on curves of 1 000-m. (50 chains) ra-

dius or greater, except the *French State* which limits the cant to 30 mm. (1/8″).

When the whole of the points and crossings is laid on the level, it is possible and sometimes useful to give the turnout line a slight superelevation by notching the sleepers on the small radius of the branch, starting from the heel of the blade.

In the same way, when the points are given superelevation, the superelevation of the straight line or of the branch line beyond the points can be obtained by using wedges to raise one of the files of rails or by notching the sleepers as in the previous case.

The *French Nord* uses this method to give a slight superelevation to both directions of a symmetrical double-curve points on the level. This railway gives the whole of the points a slight superelevation when the branch has to be taken at speed. This superelevation which may amount to 10 cm. (3 15/16″) has been found in practice not to have any appreciable effect on the way the vehicles take the through line at speed.

The maximum speeds in use with the different methods of laying on the straight, or through curves over points, with or without superelevation, are given in table 19.

The *French Est* and *P. L. M.* alone allow vehicles to run at 120 km. (75 miles) onto the branch through 0.05 symmetrical points of large radius (over 2 000 m. = 100 chains) laid without cant. On the *Alsace-Lorraine* the speed is not allowed to exceed 100 to 110 km. (62 to 68.3 miles) an hour, on the *French State* and *Rumanian State* 90 km. (56 miles) and 80 km. (50 miles) respectively, and on the P.O.-Midi and *Jugoslav State* Railways a maximum of 70 km. (43.5 miles) an hour.

When the points are given some superelevation the *Alsace-Lorraine, French Est, State* and *Nord* do not reduce the speed on the through road except in special cases.

This question does not arise on the *P. L. M., Rumanian* and *Jugoslav State* Railways, on which the points have no superelevation. On the former Company there is no restriction on the through road, the second limits it to 110 km. (68.3 miles) and the third only allows the trains to run on the through road at 80 to 100 km. (50 to 62 miles) an hour according as to whether the points are taken facing or trailing.

The railways consulted do not as a rule consider the maximum speeds through the points and crossings now in use should be increased.

The *French Nord* which thinks improved running could be obtained by welding the joints, has designed and recently tested, as we have already reported, tangent 0.05 crossings with flexible tongues fitting into a planed recess in the special section rail with a 40 mm. (1 9/16″) thick web and with the point chairs welded to plates.

In some cases, the branch is a circular curve and in others the track is laid on a parabolic transition the whole length of the points and the connecting rails to the point of the crossing.

Two sets of points and crossings of this type, with parabolic turnout, have recently been laid at one of the *French Nord's* most important junctions. Tests will be made as soon as the corresponding equipment and lines on each side are quite in order.

The principal characteristics of these points are given in Tables 17, 18 and 19. The only differences in the circular turnout now being built are :

Angle of the crossing : 25′ instead of 45′;
Length of the points : 14 m. (45′ 11″) instead of 12 m. (39′ 4 1/2″);
Length of the monoblock nose : 8 m. (26′ 3″) instead of 8.20 m. (26′ 10 13/16″);

TABLE 19.

Maximum speeds points can be run over according to the way they are laid.

ADMINISTRATIONS.	Pattern and year first points of this type were laid.	Total length as laid.	Maximum speeds allowed on to the branch line.					
			the through road being on the straight			the through road being on a curve		
			points level.	points laid with cant		Direction of the turnout.	the points being level.	the points being laid with cant.
				Amount of cant.	Speed.			
			km./h.	*millim.*	*km./h.*			
Alsace-Lorraine	tan : 0.05 (1934).	56.54 m.	...	About 20 mm.	100	This case does not arise with points taken at high speeds.		
French Est.	tan : 0.05 on branch.	58 m.	90	20	100	Speed governed by lack of cant which must not exceed 90 mm.		
	tan : 0.05 symmetrical (1926).	58 m.	120	...	...			
French State	tan : 0.06 (1930).	54 m.	80	30	90	In same direction as main-line curve.	Speed varies with the radius.	
						In opposite direction to the main-line curve.	90 km./h.	50 km./h. when the branch can be restored to level by notching the sleepers.
French Nord	tan : 0.05 with parabolic turnout 1936).	62.681 m.	To be determined during trials to be made shortly.			The speed is calculated for each case.		
	tan : 0.06 on branch.	45.70 m.	80	80 to 100	100			
	tan : 0.06 symmetrical.	50.51 m.	100	...	...			
	tan : 0.07 on branch.	42.09 m.	70	80 to 100	90			
	tan : 0.07 symmetrical (1904).	45.90 m.	90	...	...			
Paris-Lyon-Méditerranée (P.L.M.)	tg : 0.05 { symmetrical	58 m.	90	No turnouts laid with cant.		In the same direction as the main-line curve.	70	...
	Est type { turnout	58 m.	120				...	...
	tan : 0.06 on branch.	47.20 m.	70				60	...
	tan : 0.06 symmetrical.	47.20 m.	120				...	...
	tan : 0.07 on branch.	...	50				50	...
P.O.-Midi (France).	tan : 0.07 (1930).	38.43 m.	70	...	70	In direction opposite to the main-line curve.	70	...
Roumanian State.	tan : $\frac{1}{14}$ (1923).	42.012 m.	80	Not done.		Not done.		
Yugoslav State	tan : $\frac{1}{14}$ (1928).	41.405 m.	facing : 60 trailing : 70	Not done.		Not done.		

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Total laying length { One-sided : 53.499 m. (176′) to 62.681 m. (205′ 7 9/16″);
Symmetrical : 53.509 m. (176′ 3/8″);

Radius of the branch { One-sided : 1 020 m. (51 chains);
Symmetrical : 2 040 m. (102 chains).

General safety measures.

When points (especially facing) are taken at high speed, a certain number of safety precautions have to be taken.

The arrangements the railways have adopted consist in controlling the position of the blade near its point and locking the blades when in position.

This control is absolute, i. e. the signals protecting the route given can only be taken off when all the points involved are in their correct position. The control is either temporary when it only acts whilst the route is being set up, or permanent if it lasts after the route has been given, i. e. if the signals automatically go to danger when the blades are moved and no longer are in a safe position.

The points are worked either mechanically or with the aid of motors which supply part or all the power required to move the blades and operate the blade locks.

Long blades are frequently operated at two points at the end of the blade and half way between it and the heel. Alternatively they are connected by rods in such a way as to conjugate their movement over their whole length.

* * *

SUMMARY.

PART ONE.

CHAPTER I.

The caracteristics of present-day vehicles.

I. Axle loads, which have increased steadily during recent years, now reach 20 tons and sometimes over and have a tendency to rise to 22 tons, the figure towards which the mechanical engineering departments are moving.

II. When studying the vertical stresses to which the track is subjected, allowance should be made for the dynamic effects of the moving parts, such as the vertical hammerblow which increases the static load of the axles or modifies the total weight distribution over the frame of the vehicle.

III. It is desirable that by better balancing the moving parts and by suitably distributing the dynamic effects, carriages and locomotives be designed so as not to add to the stresses in the track and even reduce the forces set up by present loads running at ever increasing speeds.

IV. While making it easier by means of suitable arrangements for the vehicle to negociate curves, the way the wheels, trucks, bogies, etc. and the whole of the frame are guided should be closely investigated. The behaviour of a vehicle on the track must be observed carefully during tests at progressively increasing speeds. The reactions and the forces recentering the various axles, especially those carrying the heaviest loads, must be calculated and measured so that lateral forces beyond the capacity of the track are not imposed on it.

V. Tests and measurements should be carried out before raising appreciably the speed of existing vehicles, even though both the vehicle and the track have caused no complaint at the usual speeds.

* * *

CHAPTER II.

Present-day main-line permanent way.

VI. Most railways have taken advantage of the general recommendations on the resistance of rails to breakage and to wear agreed in 1930 at the Madrid Congress. However improved the rails may be as regards manufacture and however more stringent the specifications be, the heavy loads and high speeds of present-day traffic impose on the track, and therefore on the actual metal of the rail, stresses any increase in which will be difficult to accept to any extent in the future.

VII. One of the improvements which have given good results, and therefore one to be followed up, is proper heat-treatment. When properly carried out, it raises the strength of the steel but necessitates careful attention being given to the metal during manufacture to get satisfactory quality, especially homogeneity. Special steels which are in almost general use for certain parts in points and crossings can also improve the behaviour of rails.

VIII. The principal railways use rails weighing 45 to 50 kgr./m. (90.7 to 100.8 lb. per yard) on their most heavily loaded sections. No conclusions can yet be drawn from the trials with heavier rails. In view of the much higher stresses resulting from heavy loads and very high speeds it is to be hoped that a heavier rail of well designed section will be rolled by suitable manufacturing methods, for use in sections carrying heavy high-speed traffic.

IX. The joint is a weak point in the track and is one of the causes of the track becoming loose, especially under heavy loads. Stiffer fish-plates improve the running of the stock and the life of the track.

X. On the other hand, a reduction in the number of joints is desirable as it makes it easier to keep the track aligned and correctly levelled, hence to run at high speeds with less trouble, maintenance costs being reduced at the same time. The use of long rails is therefore to be recommended, provided the safety of the traffic is fully ensured by the rails being free to expand without any restriction likely to endanger the stability and equilibrium of the track.

Investigations and tests leading to practical results in this field will give appreciable improvements and economies in the behaviour and maintenance of the track.

XI. One of the immediate consequences of working heavy loads is an increase in the number of sleepers per unit length.

The wood sleeper is the best for high speeds.

XII. Rail fastenings should meet three requirements.

— prevent the foot of the rail from damaging the top face of the sleeper under heavy loads;

— maintain the correct gauge of the two lines of rails by preventing any side slipping through flange thrust;

— prevent the rail from tilting under flange thrust.

This can be obtained more easily by laying the rails on bearing plates to which they are rigidly fastened quite independently of the fastenings holding the rails to these plates.

Careful supervision is needed when laying rails directly on the sleepers. An improvement is to interpose packing of some soft or elastic material as this prevents the rails being driven into the top of the sleepers under very heavy loads.

XIII. Increased loads and speeds involve an increased depth of ballast between the sleepers and the formation in order to distribute more evenly the pressure transmitted through the rails.

In order that the ballast may form

compact, strong, and sufficiently yielding layer, it should be made of rough, hard, and angular material, such as broken stone well screened and uniform in quality and size.

The present-day tendency is to make the layer of ballast immediately under the sleepers of small material, not exceeding 6 to 7 cm. (1/4″ to 9/32″) in its largest dimensions. Even smaller material, 4 to 5 cm. (5/32″ to 3/16″) at most or flat chippings are sometimes used successfully and give a relatively elastic layer. This material is very easy to handle and facilitates track maintenance.

XIV. The formation and structures, the base and foundation of the track, should, if needed be consolidated and protected as necessary to withstand permanently all causes tending to weaken them, such as loads, thrusts, or shocks acting either directly or through the ballast.

The formation should be made sound and drained when needed by using, for example, layers of fine material under the ballast to prevent the latter being driven into the road bed and consolidated as necessary by earthworks or masonry walls, etc... which enclose the ground and drain water.

Each time the load or speed is raised, the bridges should be designed, proved, and supervised, by calculations, tests, and measurements, and strengthened as found necessary.

It is much to be desired in this connection that experiments be made to ascertain the actual value of the forces acting on the different details or parts of the structures and the exact effect of speed on these forces.

XV. The guiding of vehicles on the track can be improved by limiting the play between the wheel flange and the rail head, as a result of narrowing the gauge on the straight as well as on curves.

XVI. The layout and the levelling of the curves should be minutely studied and adjusted. The effect of heavy loads on curves is particularly serious on the lower line of rails.

High speeds involve progressive transitions of sufficient length onto and off the curves with corresponding changes of superelevation in order that the vehicle may be regularly guided onto and off the circular parts of the layout.

The circular parts of the layout should be given the superelevation required for the maximum speeds so as to avoid any excessive lateral thrusts through centrifugal force and any shocks which might result therefrom.

On lines with relatively sharp curves, less than a thousand metres (50 chains) radius, it is therefore sometimes difficult to conciliate the running of very high-speed vehicles or trains with that of heavy rakes at lower speeds.

CHAPTER III.

Modernising old track for heavy loads moving at high-speed.

XVII. There are still no railway lines specially built for heavy trains and very high speeds.

Such traffic is still worked over the main-lines of the large systems without any other strengthening of the track than that usual when relaying.

The railway track in fact has not been appreciably altered for some ten years.

At the present time the design and strength of the track on the main-lines is such that no appreciable increase in load and speed is possible without serious alteration and strengthening of the equipment.

Any further increase in these two factors may lead to excessive stresses in the track as previously built, and involve more frequent and more extensive maintenance.

XVIII. The modernisation of existing tracks can only mean a long and exacting work in the course of which the

following points, given in the order they could be dealt with in succession :

— The number of sleepers per unit length should be augmented, so as to increase the number of points at which the rails are supported, to make the whole track more rigid and to distribute more uniformly the pressure exerted by the track over the ballast.

— The thickness and if necessary the quality of the ballast should be increased to give the desired consistency and to distribute the effects of the rolling loads regularly over the formation.

— The existing rails should be replaced by heavier rails to suit the axle loads and the forces of all kinds the track has to stand.

— A stronger rail section should be designed, if it is found possible to manufacture such rails from suitable steel.

— The joints should be improved and stiffened to make the rail assembly as rigid as possible.

— Expansion joints should be used which allow longer rails than the present ones to be used, so as to reduce the number of joints per unit of length.

— The fastenings should be so improved so as to ensure the rail being strictly immovable on the sleepers and to prevent the latter being damaged.

XIX. The fastenings, when properly designed and used, should also increase the lateral rigidity, and therefore the general stability of the track. Such fastenings should be used especially on the curves and approaches. The same result can be obtained by the use of various devices such as cross ties, longitudinal ties, etc... which prevent the lateral deformations of the track.

XX. These various improvements can only be considered when the layout is free from too sharp curves, which cannot be run over at high speeds.

The maximum superelevation being about 18 cm. (7″) the maximum speed cannot exceed 140, 130 and 120 km. (87, 80.8 and 75 miles) an hour on curves of less than 800, 700 and 600 m. (40, 35 and 30 chains) respectively.

These figures are maxima and the speeds to be authorised can only, as a rule, be decided after trials, taking into account the location and the particular features of the line, such as the layout of the curves and the transitions.

The design of railcars and motor trains is such that they can often be allowed to run through curves at slightly higher speeds than the ordinary trains.

PART TWO.

Points which can be taken at high speeds.

XXI. Very high speeds require a track in perfect running order. The equipment must be in good condition, the layout and the level maintained very regularly, and the track must be gone over as often as necessary.

The intervals between repairs and the tolerances allowed must be tightened up, with a proportionate increase in the supervision of the track, the work of the maintenance gangs, hence of the costs.

This should be borne in mind before deciding to introduce new locomotives which would allow the speeds over a line or section to be increased considerably.

XXII. High average speeds are only possible when there is no need to reduce speed at junctions. In such cases special points and crossings are needed so that the turnoff as well as the through road can be run over at high speed.

The general principles based on experience in this matter seem to be the following :

XXIII. As regards the layout, turnout curves should be designed as carefully as those on the running track.

Any break in the layout should be avoided, and the angle of tongue with stock rail should, therefore, be kept as small as possible.

The vehicles should be guided continuously and consequently there should not be any widening of the gauge in any part of the points and crossings on either line.

XXIV. Points and crossings to be run over at high speeds should be designed on the following principles :

— The blades should be long and preferably flexible, and the heel be fixed to ensure perfect continuity of the layout between the blade and the rails connecting it with the crossing;

— The point of the crossing should be very rigid and preferably in one piece;

— The fastenings for rails and special fittings should be as strong and rigid as possible;

— The number of joints in the rails and special fittings throughout the points and crossing should be reduced so as to lessen the effect of shocks.

XXV. Points and crossings can be laid in a through road, on the straight or on a curve, with or without superelevation according to local conditions and requirements.

Some superelevation can be given on the straight road to improve the turnout, and the difference in level between the two lines of rails can be gradually altered by notching the sleepers, by inserting wedges or any other suitable means.

The maximum speeds points can be taken depends on the layout, the design of the points and the way they are laid. They should be determined for each direction experimentally.

They may also depend on certain general safety precautions which should have attention like the track itself.

[385. 57]

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

13th SESSION (PARIS, 1937).

QUESTION XI.

Selection, orientation, and instruction of railway staff.

REPORT

(Italy, Spain, Portugal and Colonies, Great Britain, Dominions and Colonies, America, China, Japan, Egypt),

by Pietro LO BALBO,

Chairman of the Board of Directors,
Dogliani-Monchiero Tramway Company Ltd. (Italy).

A problem of the greatest interest and which is very much to the forefront today is that of the selection, professional guidance and instruction of railway staff. Psychotechnics, applied to the study of this problem, have henceforth definitely become an institution : there are no important railway managements who do not make use of psychotechnical tests when selecting candidates for services involved in safety of transportation.

Therefore, professional guidance creates a new form of social work, capable of rapidly guiding young men, once their education is completed, towards professions or trades for which they are best suited; psychotechnics can contribute a great deal to such an important branch as transportation, by making it possible to have both an efficacious preventive hold over the capabilities of staff and a rational distribution of their individual capabilities.

Our investigations into this important problem covered the following countries : Italy, Spain, Portugal, Great Britain, its Dominions and Colonies, Egypt, North and South America, China and Japan, viz. countries in which the length of railways operated amounts to 280 111 km. (174 130 miles) or seven times the circumference of the earth. The actual staff directly employed by railway companies in those countries numbers 2 325 750 in all. The outlay for this staff amounts on an average to 60 % of the total operating expenses : therefore, if this percentage were only slightly lowered, considerable savings would be effected as a result. If in the past savings on staff expenses have been chiefly obtained by cuts in wages, at present it appears preferable to achieve this object by increasing the efficiency of the staff, which is the aim of the education, selection, and professional guidance of railway staff.

This question which has been and still is the source of continual preoccupation has already, in one shape or another, been placed several times on

the agenda of the Sessions of the International Railway, Congress Association, viz :

1. At the Milan Congress (1887) under the heading : « Organizing, appointing and training staff »;

2. At the Paris Congress (1900) : « Technical education of railway servants. Appointment and promotion », with the following sub/title : « attempts made by the railway administrations to promote the technical education of their staff ».

3. At the Madrid Session (1930) : « Methods to be followed in the training of staff : professional, technical and ordinary working grades ».

At the latter Session the very interesting reports by Messrs. BARTH, MEREUTZA, FRITCH and SCHWARZE dealt in particular with the education of staff and stressed, among other things, the advisability of psychotechnical examinations when appointing staff for the operating services.

Without going into a detailed review of the question, we should like to-day to give some information as to what has been achieved from the special standpoint of psychotechnics and as to what in recent years has become current practice in railway management from the point of view of education and professional guidance of staff.

In *Italy* the celebrated biologist Angelo Mosso has, in his remarkable works on the analysis of movement, set forth the psychological laws of fatigue. But it was only in 1918 that the medical department of the railways pointed out the importance of making a good selection of railway employees who would be put in charge of operating safety, and that such candidates were for the first time subjected to summary psychological examinations of their nervous systems. The head of the medical department at that time, Dr. G. FABBRI, issued regulations for admitting employees to office work, and in these regulations we see that there are included examinations for sensibility, attention, perception, and so forth.

Concrete proposals regarding psychotechnical examinations were made by the official railway consulting physicians, Professors TANZI, DE SANCTIS, BRUGIA, MODENA, TIRELLI and others.

In 1924 several doctors of the railway medical service attended psycho-physiological inspections to which candidates for the Air Force were subjected. Professor DE SANCTIS, the railway neuromental specialist, gave at that time lectures to railway medical officers and drew up several formulæ for the psychotechnical examination of engine drivers and firemen.

Attached to the Central Medical Bureau of the State Railways, there was founded, in 1934, a psychotechnical laboratory provided with appliances for making the more important tests specially resorted to when examining railcar drivers. There has now been added to this special bureau a consulting physician for psychotechnics, viz. Professor PONZO.

Several railway medical officers have dealt, in various publications, with psychotechnical examinations (1).

Professor DE SANCTIS, in particular,

(1) S. DIEZ : A problem of concrete scientific organisation of work *(Rassegna Previdenza Sociale*, 1923).

A. KNIPFER : Psychotechnical examination of locomotive staff. 1923.

G. TOMAI : Selection of railway staff from a physical and psychological standpoint. — Prato Tip. Partini, 1925.

A. CIAMPOLINI : Psychotechnics for the selection of locomotive staff for the State Railways, 1925.

A. FILIPPINI : Psychotechnical selection of railway staff. — *Revista tecnica delle Ferrovie italiane*, 1929.

A. FILIPPINI : Railways and level crossing accidents. — 2nd Congress of psychotechnics applied to the prevention of accidents. Rome, 1932.

A. FILIPPINI : Psychotechnical selection of drivers of fast vehicles. Medical treatise on transportation. — Union Tipografico Editrice Torinese, 1930.

has published a whole series of theoretical and practical treatises of the greatest interest, and in their turn Professors Filippini and Ponzo, with the collaboration of Professor Banissoni, have given lectures and made applications of psychotechnics and professional guidance to railway staff. However, only the following classes of personnel have to undergo psychotechnical tests : locomotive drivers, firemen and railcar drivers.

The education and training of new hands taken on by the various railway services take place gradually : apprentice-firemen (who after long practice become drivers) and drivers of electric locomotives and motor coaches follow special classes. Certain particular courses are held for given specialised work (electric welding, inspection and acceptance of wooden and iron articles, commercial science for managing officials). Instructional courses are furthermore held for candidates appointed inspectors of the locomotive and rolling stock department, the permanent way inspectors, etc. The *Dopolavoro* (« After Work » organisation of the railways) organises special instructional courses (telegraphy, general tuition, etc.).

Official decrees were promulgated (circulars 4517, 4800 & 5089) for the purpose of regulating the psychotechnical examination of office employees.

Like all the other branches of the medical service, the laboratory comes under the purview of Dr. G. Pagliano, Chief of Department, and is under the direct management of Comm. Dr. Azeglio Filippini, assisted by Professor Mario Ponzo, psychotechnical specialist, and Ing. Fanelli of the locomotive and rolling stock department.

In the course of their studies on the selection of railway staff, psychotechnical research workers have given preference to the individual analytical method. Nevertheless, the basic idea of recent research by Professor Ponzo has the merit of being all-embracing because it permits extending psychotechnical study of individual persons to that of their surroundings, i.e. it allows one to take account of all the circumstances, complete them, and thus attain the practical aim of such research work : safety in railway operation.

At the present stage of psychotechnical selection, as practised by the Italian State Railways, the only compulsory examination is that of the specific senses and of the nervous system, which is made in the course of the general medical examination held prior to entering the service and which is repeated at the age of 45 in the case of employees working in the locomotive running department.

In the case of locomotive drivers and railcar drivers, tests are at present carried out concerning :

a) capacity for attention;
b) diffused attention;
c) time for reaction;
d) « tapping » test;
e) the ergograph.

The employees willingly undergo these tests and many of them take an interest themselves in such researches (2).

(2) Speaking generally, it can be stated that Italy much favours the development of psychotechnical applications, as psychotechnics are now considered a necessary factor in the favourable development of working conditions and not only as an instrument of value to the employer alone.

Indeed, within certain fascist worker's syndicates, labour research centres have been created (which operate under the guidance of university professors of experimental psychology) in close cooperation with the obligatory labour exchanges and with all the labour organisations, and the results obtained, especially at Turin by Comm. Dr. Augusto Venturi (prov. Secretary of the Federation of industrial workers), are excellent, as the psychotechnical examination is in perfect cor-

At the « Azienda Tramviaria » of Milan (A. T. M.) Professor CORBERI founded in 1925 a psychotechnical consulting-room where the following tests are carried out :

a) Tests of the senses (chromatoscopical examination; visual field for white; sound direction);

b) Selective tests : appreciation of the variation of speed and distance (by means of *Giese*'s apparatus and the *Mira* tachodometer); test with the *Netschajef* tachostoscope; diffused attention (the special *Ferrari-Corberi* modulus); time of visual reaction recorded by means of *Hipp*'s chronoscope; plethysmography; ergography (*Mosso* ergograph); motive suggestivity (*Binet*'s appliance); emotivity.

Recently, under the same management, Professor MASSAROTTI has made certain changes in the research methods mentioned above, in order to compare as far as possible these psychological researches with clinical reality, and the latter with labour reality. Above all, he makes anthropometro-somatic examinations of the sensorial and neuropsychic organs. After that, he carries out psychotechnical examinations for the purpose of corroborating and completing the diagnosis based on the preceding tests.

The psychotechnical examination includes the following essential tests : ascertaining the times of reaction, rapidity of perception and diffused attention (figs. 1, 2 and 3).

The results achieved by Professor MASSAROTTI have clearly proved, in the opinion of the Azienda Tramviaria of Milan, the great utility of psychotechnical examinations and produce, for the operating of that concern (thanks to the decrease of accidents), an annual saving of several millions of lires which otherwise would have had to be paid as compensation.

* * *

In *Spain* it was M. German ASUA, chief medical officer, who initiated psycho-

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relation with professional guidance, which easily enables the young men to be drafted to the various branches of productive activity.

Italian psychotechnics will soon, in all the posible spheres of their activity, bear the imprint of this new spirit, inspired by social discipline and the vision of all-round final results which their application is bound to achieve.

Professors Colucci, Gemelli, Credaro, Orestano, Ponzo, Banissoni, Bonaventura, Castelli, Sergi, Fusco, de Salvo, Resta, Ferrari, Musatti and many others are dealing with the greatest zeal with this science. On another hand, it must be remembered that psychotechnical examination of personnel attached to the operating services of the Italian State Railways, as elsewhere, fulfils aims that are of evident public interest and as these examinations give very good results they are well supported in Italy by the public authorities. During the last ten years there has been a constant decrease in the number of railway accidents : indeed, a comparison between the average of the two years 1924-1925 and that of the two years 1934-1935 shows a decrease of 86.23 %. Moreover, during those ten years there has been a large drop in the number of victims of accidents : from 753 killed and 4139 injured in 1924-1925 the respective figures fell to 420 and 1012 in 1934-1935.

The psychotechnical laboratory of the Commune of Florence contributes, by its activities, to an ever greater diffusion of the principles of psychology applied to work in general and to the professional training of young men in particular, as it provides at the same time a scientific examination of the various psychological and psychotechnical problems encountered during its daily routine.

M. Fossati's psychotechnical laboratory at Turin is also hard at work. It draws up, among other things, a list in which the physical, moral and intellectual qualities are divided for each category of personel into 4 degrees : excellent, above the average, average and insufficient This system is based on a preliminary determination of the *average value* shown by the personel for each characteristical average value obtained after having examined the largest possible number of subjects.

Fig. 1.

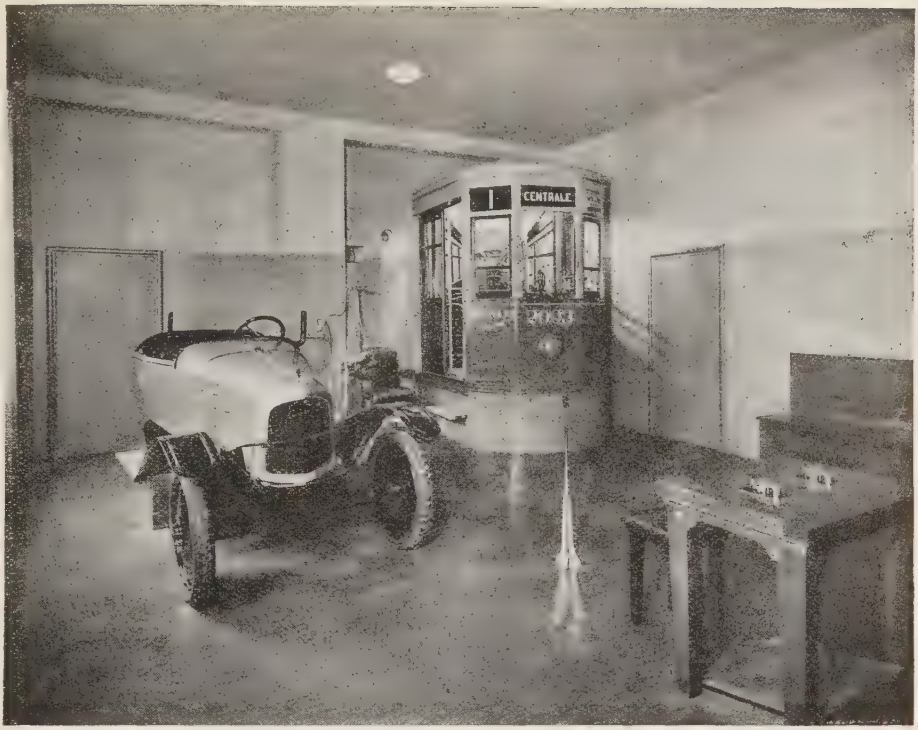
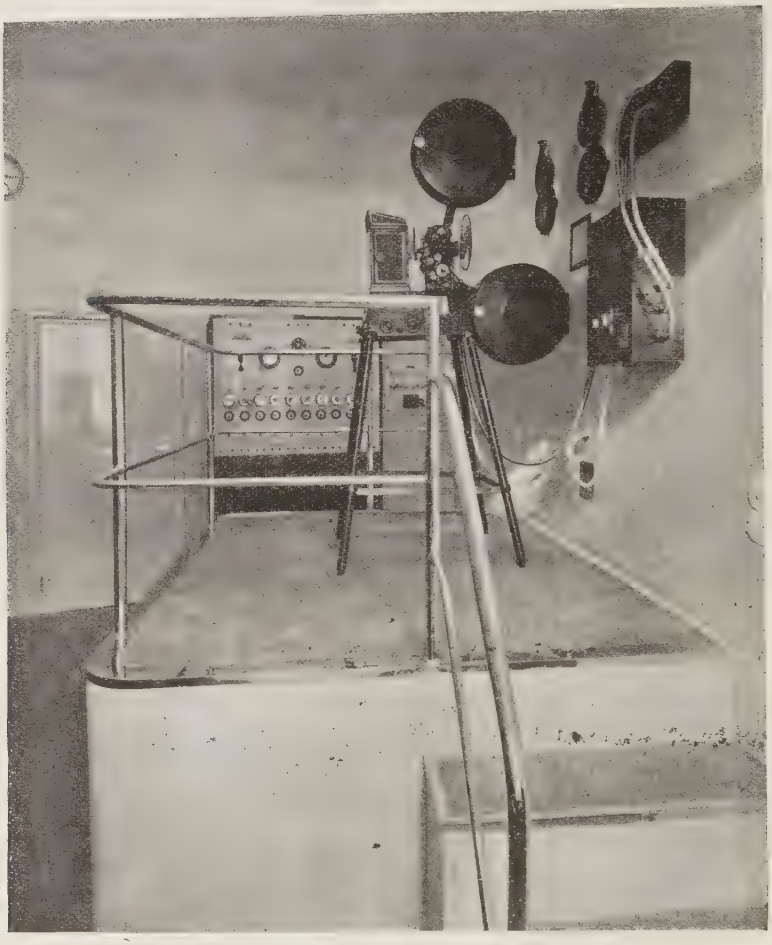


Fig. 2.



Figs. 1, 2 and 3. — Details of test room for professional movements.

The subject is placed in a dark room, at the steering wheel of a road motor car, or the controller handle of a tramway motor coach or railway motor car, and while a kinema film is being shown him to distract his attention, he has to respond to the various signals which appear from time to time at several places on the edge of the screen (red light : stop — green light : slow down — white light : proceed at speed) by acting as he would normally do in service (actuate brakes, whistle or bell, accelerator, etc.).

The luminous signals are produced automatically, and the acts of the subject are also recorded automatically, so that testing conditions are identical for all candidates. This constitutes a synthetic test for rapidity of perception, reaction times and diffused attention.

technical tests of railway personnel. But it was only in 1934 that psychotechnical research began to be applied to railway staff (at Madrid, Barcelona and Valladolid) and its results were made use of for the selection, professional guidance and instruction of such staff. These psychotechnical laboratories are managed by a physician; only apprentices and railcar drivers are examined.

The education and training of new employees for the various departments of the railway are conducted in a very simple manner : a start is made with simple duties and after a certain time such employees undergo aptitude tests or examinations for promotion to higher grades. For certain categories, employees who do not possess a minimum of knowledge or aptitude are rejected.

Candidates wishing to become railcar drivers are submitted to the following tests :

a) intelligence;
b) concentrated attention;
c) diffused attention;
d) reaction when faced with visual or audible obstacles;
e) estimating speeds and distances.

Workshop apprentices undergo the following tests :

a) intelligence;
b) attention;
c) manual skill;
d) mechanical aptitude.

The groups of apprentices are then classified according to the « Cuartiles » system in the following grades : « very good », « good », « ordinary » and « bad ». Those in the latter grade are rejected, whilst the others are engaged according to their qualifications.

The coefficient of correlation between the psychotechnical estimations and the opinion of the respective department is 80 %.

Employees subjected to these psychotechnical examinations are at first somewhat surprised, but later on they submit themselves willingly to such tests, even with a certain amount of curiosity.

In *Portugal* there are no laboratories for psychotechnical tests. For the admission, promotion and medical examination of railway officials and employees there are only the medical services of the railway itself, comprising specialists for the eyes, nervous complaints and so forth, and who also attend to the staff when required.

In *Great Britain* and the *United States of America* there is nothing in existence as regards psychotechnics applied to railway staff. Nevertheless, it should be pointed out that in these two countries great importance is attached to rational education of railway servants attached to operating services, an education that may be considered as integral and complete. Examinations are ordered for those seeking promotion.

As to drivers, the system of apprenticeship in force is excellent in all respects. The U. S. A. are indebted to Munsterberg for the first researches as to the causes of railway and tramway accidents; he made these investigations on behalf of the American Association for Labor Legislation. At first he met with some hostility, but later on, institutions for professional guidance were founded in the principal cities in North America, and they always showed good results.

In *South America* there are no real psychotechnical laboratories. When staff is recruited, there is an examination for :

a) apprentice engineers (mechanical and civil engineer's departments);
b) learners (traffic department);
c) workmen of all grades.

On the Buenos Ayres Great Southern Railway, candidates under *a*) and *b*) must not be over 18 years of age and must possess a diploma from the Cambridge School or a similar di-

ploma. They must undergo the medical examination prescribed by the railway companies, particularly as regards their sight, mental faculties, and physical fitness. They must sign a special contract for the whole period they are on probation; otherwise, they come under the general service conditions applying to staff. When they are admitted into the company's service they must attend practical training courses, during which they may be transferred from one branch of the service to another, according to their aptitudes, or even dismissed. At the end of the year they have to pass an examination on the matters they have studied, and those who fail are eliminated. The courses usually last 5 years on the whole, and it is from the young men who have successfully passed them that the company eventually selects those who are to be appointed to the permanent staff.

In *Egypt* psychotechnics are not applied.

In *Sudan* there are good methods in existence for professional training of staff (the Railway School at Atbara). No railway servant can perform the duties of a rank for which he does not hold the corresponding certificate of capability.

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In *India* special care is taken with professional guidance of staff who have to attend practical and theoretical courses. The pupils pass examinations held by Boards consisting of railway inspectors.

The North Western Railway has created at its own expense a professional training and improvement school for the staff, more especially for station masters, clerks, inspectors for the track maintenance, signals and bridge services. The results achieved are excellent and the Government of India has recently founded a training institution which enables young men to serve an apprenticeship fitting them to enter the service as mechanical or electrical engineers on the railways.

* * *

In *China* there are training schools the expenses for which are borne by the Ministry of Railways with the aid of the transport undertaking. The results are remarkable.

Staff of outdoors operating service serve an apprenticeship of one year during which the pupils attend 15 courses (legal provisions governing railway operation; general regulations as to the running of trains; railway accountancy; locomotives and plant; telegraph; traffic control; rates, etc.).

For operating employees (assistant signalmen, brakesmen) the age on entering the service is 18 to 24 years; they must possess a certificate of elementary education and pass an entry examination. For the young men admitted, the period of apprenticeship is 6 months during which they study the principles of mechanics and regulations on train running.

Examinations are held twice a year by travelling examiners, appointed by the General Manager. The subjects relate to the programme studied and the work each employee will be called upon to perform.

Staff destined for the locomotive and rolling stock department start with an apprenticeship (admission age 15-1 years, and certificate of elementary education demanded). This apprenticeship lasts 4 years. Examinations, either theoretical or practical, are held each year. After these 4 years, only the best pupils are promoted to the rank of fitter's mate or assistant mechanic. And successively as vacancies arise, they are drafted on to the locomotive department, the best men always being given priority.

* * *

In *Japan* the railways have a system of professional apprenticeship for the various categories of station and train staff, for office employees, locomotive drivers and shopmen.

These courses are held at times of the year chosen according to circumstances and last from one to six months.

The education is usually acquired by experience gained in the various grades of the service.

* * *

SUMMARY.

From the replies received, and summarised above, it will be seen that selection, professional guidance and education of railway staff cannot be considered at the present time as being applied to the fullest possible extent.

If it is true that all the large railway systems have organised professional education, sometimes optional but in most cases obligatory, with periodical examinations, it must be admitted that such education although it constantly tends to become more perfected, is given to apprentices on rather varying lines : on certain railway systems it only embraces manual work; on others, the teaching is theoretical; others again provide a general education.

As regards selection, professional guidance and instruction of railway staff, in all countries covered by this report, candidates are required to show proof of general education in keeping with the initial position they are to occupy in the railway service; professional training of the railway servants takes place while they are actually on duty, during probationary periods, and in most instances they ascend successively to the various grades. The results are satisfactory; but it is admitted that it is necessary, in the first place, to select railway servants from those candidates who show the best signs of health and education, and in the second place to only admit to duties connected with the safety of operation such railway servants as have been considered fit to perform them after serving a practical apprenticeship.

Up to the present only the more important railway and tramway undertakings apply the new methods of selection, based on psychotechnical tests, to the traffic, locomotive running and workshop staff. And it is above all on such railways that the results obtained are really remarkable and that there is an appreciable decrease in the number of accidents due to lack of attention or of reflexion, to indecision of occasional or habitual timidity, to excessive speed, etc.

The psychotechnical reference cards drawn up by the laboratories have always shown the closest concordance with the opinions of the heads of the departments concerned, which in turn allows of the selection of the candidates best suited for the service, viz., those who will prove most efficient and thus help to lower working expenses. This is another confirmation of the efficacy and utility of applying psychotechnical tests to railway staff.

Indeed, the problem is not only one of using the mens' capacity for work in the manner least dangerous from the point of view of accidents and most profitable from the output standpoint but also of applying it in the way most profitable to the worker himself. And thus, requisite importance must be attached, not only to the education of the staff and their guidance, but also to the working conditions, the somato-physiological qualities of movements (actions), the force exerted, endurance to fatigue, investigation into the movements required to carry out a given job, and finally to the capacity for development of the individual qualities of railway servants and their ability in practical service with the railways.

[385. 57]

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

13th SESSION (PARIS, 1937).

QUESTION XI.

Selection, orientation and instruction of railway staff.

REPORT

(Poland, Germany, Netherlands and Colonies, Denmark, Norway, Sweden and Finland),

by J. WOJCIECHOWSKI,

Engineer, Psychotechnical Advisor at the Polish Ministry of Communications.

In the elaboration of the present report, we have adhered to the order in which the questions were set in the list circulated to Railway Administrations of the countries assigned to us for our enquiry.

We would first of all mention that psychotechnics applied to the selection of transportation staff were first introduced in Germany (in 1917), then in Poland (in 1925), in Denmark (in 1930), and in Sweden (in 1935).

In Germany, psychotechnics were widely applied in the various fields of economic life, and in particular also in the various railway services.

The initiative for introducing psychotechnical tests on the railways in Germany and Denmark was impersonal (ordained by the Ministry of Communications or by the Railway Headquarters); in Sweden the initiator was Mr. Axel Granholm, General Manager of the State Railways, and it was only in Poland that this initiative was taken by railway engineers, viz. by Messrs. B. Skupiewski, Chief Mechanical Engineer, and S. Wasilewski, head of the Mechanical Section at the Ministry of Communications.

Railway psychotechnical laboratories are mostly managed by higher officials, either at the Ministry of Communications or the Railway Headquarters : in Germany it is by Herr Dilger, Reichsbahnrat; in Sweden by Doctor R. Anderberg, professor at the University of Upsala; in Denmark by the railway Staff Office, and in Poland by the Medical Board of the Ministry of Communications, the councillor of which is the author of the present report, who is the psychotechnical advisor to the Ministry of Communications, and is also entrusted with the supervision of the two laboratories at Warsaw and Poznan.

In Denmark psychotechnical tests are carried out either at the Copenhagen Municipal Psychotechnical Institute, or at the Railway School, or else in other similar establishments.

The following classes of railway servants undergo these tests : in *Germany*, certain grades of office employees and workmen, such as : loaders, shunters, pointsmen, train-men; certain office

staff; station-masters, assistant station-masters, booking clerks, staff in the goods despatching service, shop apprentices, locomotive drivers, railcar drivers, etc.

The obligatory tests are sometimes supplemented by special tests which enable the authorities, in case of doubt, to ascertain the value of candidates from a professional standpoint when a post involving special responsibilities is under question.

The central schools at Berlin and Hanau resort to psychotechnical methods for apprentices during the course of the training period.

In *Denmark,* candidates for the post of assistant station-master, administrative official, locomotive driver, permanent-way staff, railcar driver, and locomotive driver wishing to become a railcar driver;

In *Poland,* traffic staff of the lower and middle grades, locomotive drivers and firemen, drivers of railway motor-buses, permanent-way staff, station staff, pointsmen, dispatchers, head shunters and staff in marshalling yards;

Psychotechnical tests are nowhere adopted as part of the general education except in Germany; examples of the application of psychotechnical tests in that country have been given in the Review *Industrielle Psychotechnik.*

As far as Poland is concerned, the official regulations concerning psychotechnical examinations were given in the 1929, 1930, 1934 and 1935 issues of the *Official Journal of the Ministry of Communications.* Denmark has made no mention of them. Nor do such directions exist as regards the application, in 1922, of psychotechnics in the training of the Deutsche Reichsbahn staff.

The German psychotechnical laboratories have, in addition, a consultative committee made up of officials from the various Departments. Denmark has no organisation of this kind. On the other hand, in Poland a consultative committee was set up, but was abolished after being in existence for 5 years; at present the sittings of this committee are replaced by general lectures given by psychotechnicians working in the laboratories. In case of need, professional specialists are invited to attend the sittings of the psychotechnicians.

Present position of psychotechnical selection.

Programmes of psychotechnical tests. — The German programmes have not been stated. Certain information on this subject appears in the works of Reichsbahndirektor Schwarze.

The *Danish State Railways* have supplied us with the following programme applied to future railcar drivers, and to locomotive drivers who wish to become railcar drivers :

a) co-ordination qualities (which probably means co-ordination of movements, or actions);
b) visual reaction;
c) attention;
d) diffused attention;
e) ability to act in time;
f) ability to think (intelligence);
g) ability to carry out orders;
h) physical strength and reaction;
i) auditory nerve; distinction of colours; discerning in the dark objects slightly illuminated (extent of twilight vision).

The conditions required from future drivers are stricter for young candidates than in the case of railway servants of more mature age and already acting as drivers.

For candidates for the post of assistant station-master, the programme of tests is as follows :

a) spelling and drafting of documents;
b) skill in calculating;
c) attention (correction of wording, classification in alphabetical order, applying rates, sorting);

d) gift of memory (execution of orders, ability to remember wordings and geographical names);

in addition, it is proposed also to test the faculty of reaction.

Apprentices engaged at the Copenhagen Central Workshops are subjected to a test in keeping with the profession chosen by them.

Those *applying for the position of office clerk* (mostly women) have to undergo a test similar to that imposed on assistant station-masters, except for a few alterations.

The Danish railways have practically no psychotechnical laboratories of their own; tests requiring the use of special appliances are made at the Psychotechnical Institute of the Municipality of Copenhagen.

As far as *Poland* is concerned, the programmes of tests are those shown in the following table (p. 1562/14).

In Poland psychotechnical examinations are made of probationary engineers in some cases, and if necessary of permanent-way men.

Psychotechnical laboratories. — The Deutsche Reichsbahn has a central railway laboratory at Berlin, attached to which there are 9 other subsidiary laboratories at Berlin, Breslau, Dresden, Francfort, Hanover, Carlsruhe, Cologne, Königsberg and Munich.

These fixed laboratories each have 1 or 2 psychotechnical cars. The interior of one of these cars is shown in figure 1.

* * *

The Danish State Railways have no fixed laboratories, whereas the Polish Railways have 2 fixed laboratories and 2 travelling laboratories, or psychotechnical cars.

According to the replies received, the *number of employees examined* up to the 1st January 1936 was :

in Germany, about 200 000 candidates (20 000 to 25 000 subjects can be examined each year);

in Denmark, about 400 candidates;

in Poland, about 14 000 candidates.

As regards the statistical method used for estimating the results of the tests and the qualifications of the subjects examined, Germany, Denmark, Sweden and Poland apply the theory of probabilities. In Germany the method adopted is quite up to date and based on the Gauss curve.

Results of investigations concerning professional qualifications of subjects are represented in the form of a curve called « psychotechnical profile ».

The *qualification marks* used for candidates are as follows :

Deutsche Reichsbahn : good, passable, fairly passable, insufficient;

Danish State Railways : very skilful (5), skilful (4), average (3), below average (2), incapable (1);

Polish Railways : good, average, below average, inadmissible.

The lowest limit of professional capacity in Germany is « fairly passable ».

In Denmark it is about the same; nevertheless for the admission of workmen the heads are authorised to amend any « passable » awards so as to either accept or reject applicants.

On the Polish Railways, the lowest limit is « below average », except for applicants for the train-running service, to which only applicants recorded as « average » are admitted.

In the Reichsbahn psychotechnical examinations are made of candidates when they are taken on.

The success of a railway servant in service depends upon his efficiency, of which account is taken in the psychotechnical coefficients. When a man is disqualified he is kept in his job or transferred to another branch of the service, in keeping with his aptitude.

Unfit workers are not dismissed. Candidates for the lower and middle ser-

TESTS.	Aptitude.	Engine drivers.	Assistant station-masters.	Pointsmen.	Shunting service.	Guards and ticket collectors.	Commercial
1. Dynamometer.	Strength an steadfastness	—	...	—	—	...	—
2. Ergo-dynamograph.		—	—	—	—	—	—
3. Induction coil		—	—	—	—	—	—
4. Sphygmomanometer		—	—	...	...	...	—
5. Arsonval chronoscope.	Psycho-motive.	—	—	...	...	—	—
6. Stippling		...	—	...	...	...	...
7. Electric stippling		—	...	—	—	—	—
8. Skill test		...	...	—	—	—	...
9. Ebbinghaus test	Intelligence.	...	—	...	...	...	—
10. Intelligence and logic test.		...	—	...	...	...	—
11. Ticket board		...	—	...	...	—	—
12. Execution of orders		...	...	...	...	...	...
13. Erecting test		—	...	...	...	—	...
14. Wojciechowski drawer		—	...	...	...	—	...
15. Heider drawer		—	...	...	...	—	...
16. Memory for words	Memory.	...	—	...	...	...	...
17. Memory for numbers		...	—	...	...	...	...
18. Memory for faces		...	...	...	...	—	...
19. Memory for situations		...	...	—	—	...	...
20. Memory for orders		...	...	—	—	...	...
21. Couvé test	Attention.	...	—	...	...	—	—
22. Poppelreuter test		...	—	...	...	...	—
23. Test of diffused attention		—	—	...	...	...	—
24. Kraepelin test		...	...	...	...	...	—
25. Segregator		...	—	...	...	...	...
26. Tachostoscope		—	...	—	—	—	...
27. Heydt apparatus		...	...	—	—	...	...
28. Wojciechowski apparatus		...	...	—	—	...	...
29. Signals.		...	...	—	—	...	...
30. Movable strip apparatus		—	...	...	...	—	...
31. Apprenticeship for reactions		—	...	...	...	...	...
32. Exactitude of reactions		—	...	...	...	—	...
33. Questionnaire		—	—	...	...	...	—

vices are drawn from the line, where no psychotechnical examination is made. But for the other services, candidates are examined in the laboratory.

The German Railways' psychotechnical service is thus of a far-reaching social nature, without losing sight of the professional qualifications required for a given post.

In case of special aptitude or the desire for rapid promotion, a railway worker may undergo the psychotechnical examination before the age of 28.

On principle, a candidate must possess aptitudes corresponding to the maximum requirements of the post for which he is applying. Value is attached to special aptitude of servants for various jobs. In special justifiable cases, applicants are authorised to demand a revision of the investigations and qualification.

On the Danish State Railways, in cases where the psychotechnical examination for fireman has given insufficient results, a candidate may nevertheless keep the job he has till then occupied; he may even obtain promotion to the post of driver without any notice being taken of the result of an examination.

Candidates not admitted to the service have no right to obtain any professional information or advice whatsoever.

On the Polish State Railways new candidates are treated in the same manner; candidates who are already in service, and occupy posts entailing a certain responsibility, cannot obtain promotion if they have been disqualified as the result of a psychotechnical examination.

On the Reichsbahn the coefficient of correlation between psychotechnical estimations and the opinion of the respective service, to which the subject examined belongs, amounts to 90 % which, however, has not been checked by the mathematical statistics adopted for psychotechnics.

The Danish State Railways, in view of the small number of candidates examined, have not mentioned the coefficient of correlation.

On the Polish railways the best concordance was obtained from the examinations of assistant station-masters : 92 %; examinations of drivers give the lowest figure : 70 %. This somewhat low figure of correlation refers to tests made by means of apparatus. But the general estimation, including appreciation of mental qualifications (character), the total coefficient is decidedly higher : the coefficient of concordance amounts to 80-90 %.

* * *

As regards the favourable effect of psychotechnical tests on the reduction in the number of accidents and cases of professional illness, neither Germany nor Denmark supply data. As regards Germany, this question will be studied by the medical authorities.

On the Polish Railways, it has been possible to establish approximate statistics for the Warsaw Division alone, as the latter was the first to introduce psychotechnical tests.

Taking into consideration the number of accidents caused by the categories of workers having already undergone tests, and going back to the year 1931, the following table has been obtained :

Number of various accidents attributed to the staff :

in 1931 . . .	1 068
in 1932 . . .	225
in 1933 . . .	197
in 1934 . . .	277
in 1935 . . .	300

The annual average figure for the last 4 years is :

$$\frac{225 + 197 + 277 + 300}{4} = 249.$$

The result is that, in comparison with

the year 1931, the reduction in the number of accidents amounts to 4.34.

As regards previous years (1930 to 1925) it does not appear necessary to take them into consideration for the purpose of our report, seeing that detailed statistics for those years were not drawn up and that psychotechnical examination of personnel on a large scale was only introduced in 1929.

For the whole of the Polish railway system the number of accidents due to collisions or derailments has appreciably decreased; the figures are as follows :

in	1927	1928	1929	1930
	3.8	2.7	2.9	2.2
in	1931	1932	1933	1934
	2.2	1.9	1.5	1.6

per million train-kilometres, or :

$$\frac{3.8 - 1.6}{3.8} \cdot 100 = 58\ \%$$

reduction as compared with the year 1927.

Although other reasons must be taken into consideration, it is nevertheless permissible to conclude that psychotechnics must have contributed to a marked extent towards this result.

* * *

How have railway servants reacted to the obligation of undergoing psychotechnical tests?

The Deutsche Reichsbahn does not mention any particular reaction on the part of workers obliged to undergo these tests, seeing that the latter are imposed by the recruiting conditions.

On the Danish State Railways the obligation was only applied to a very restricted number of men who were already in the service; the tests were above all made obligatory to new candidates who were not entitled to oppose them in any way.

In Poland the railway drivers presented in 1926-27 a request to the Ministry of Communications, containing a certain amount of opposition to psychotechnical tests. This protest gave rise to a meeting between the head of the laboratory and the men's delegates; it was explained to the latter how the tests were to be carried out and as the result of a demonstration, during which several specially qualified engine drivers were invited to express their opinion and, in addition, to collaborate with the head of the laboratory with a view to perfecting the principal tests, the worker's delegates stated that they were willing to undergo this new obligation, although it had seemed somewhat unpleasant to them in the first instance.

As to the other Services, the introduction of this new obligation has not, so far, caused any conflict.

* * *

The authorities of the German, Danish and Polish railways have reported favourably as to the utility of psychotechnical examinations; they are of opinion that these examinations, apart from all other considerations, serve as a guarantee that the selection of new railway hands is not made with any ulterior motives; it thus becomes evident that Railway Managements have no other aim in view than to ensure safety.

The higher authorities of the Reichsbahn have, however, doubts as to the efficacy of psychotechnical examinations of railway hands who are already on the staff, and they are of opinion that re-examination of older employees is superfluous, as well as tests for promotion.

In Poland certain complaints became apparent as to the duration of the tests. At present we are tending to reduce the number of tests and only retain those

Professional training Institute at the Reichsbahn Central Office, Berlin.

which appear to us to be the most efficacious.

* * *

Psychotechnics applied to professional training.

Psychotechnics applied to professional training is only developed in Germany.

* * *

The results of psychotechnical tests are generally taken into consideration during practical professional training; in Germany candidates disqualified by psychotechnical tests are not accepted as apprentices.

* * *

As regards the application of the guiding rules laid down by the psychotechnical service, in Germany the staff departments carry out this duty.

Special apparatus employed.

In our questionnaire we requested the Administrations consulted to mention what special apparatus are used for educational and training purposes in the various departments.

On the Reichsbahn there are special appliances for the training railcar drivers, booking clerks, head shunters, fitters, filers, etc. These appliances are described in Professor Moede's work entitled *Arbeitstechnik*, Stuttgart, 1935. These appliances enable apprentices to practise, and contribute towards a quicker and more thorough training.

As regards the results obtained from the use of these appliances, the Reichs-

Fig. 1 to 3. — Psychotechnical test car, Deutsche Reichsbahn.

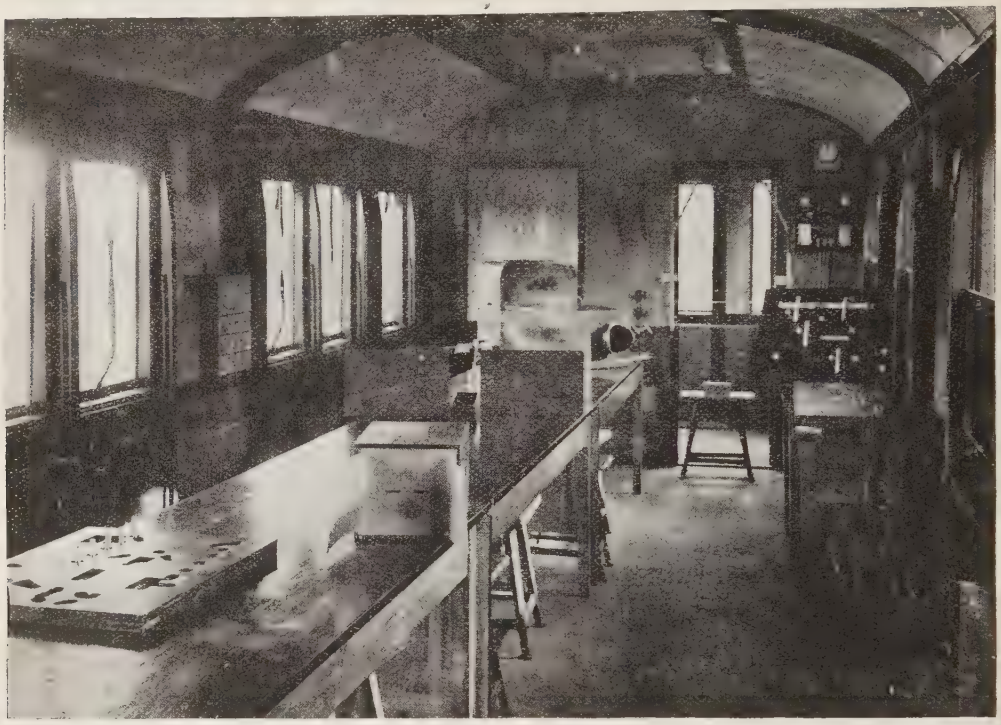

Fig. 1. — Interior view of a psychotechnical car. Installations for individual tests and test-desks.

Fig. 2. — Room for collective tests.

Fig. 3. — Outside view of psychotechnic test car of the German Railways (one c per Division).

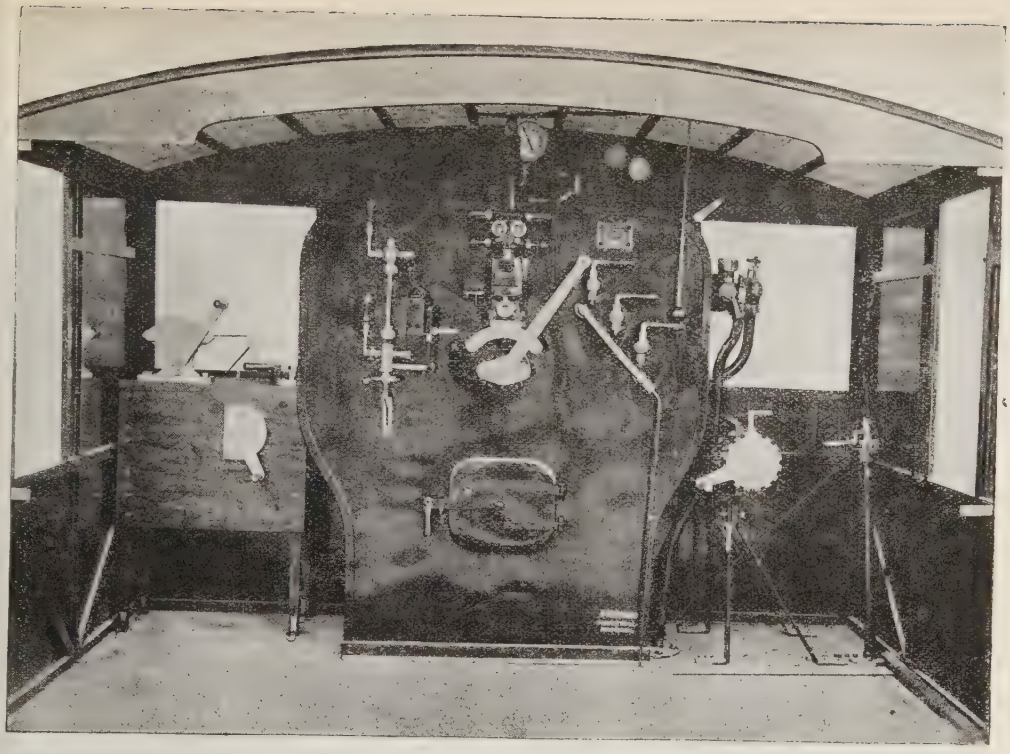

Fig. 4. — View of locomotive cab. The left hand part is used for testing diffused attention of candidates. The right hand part can be used for psychotechnical examination and training of young engine drivers.

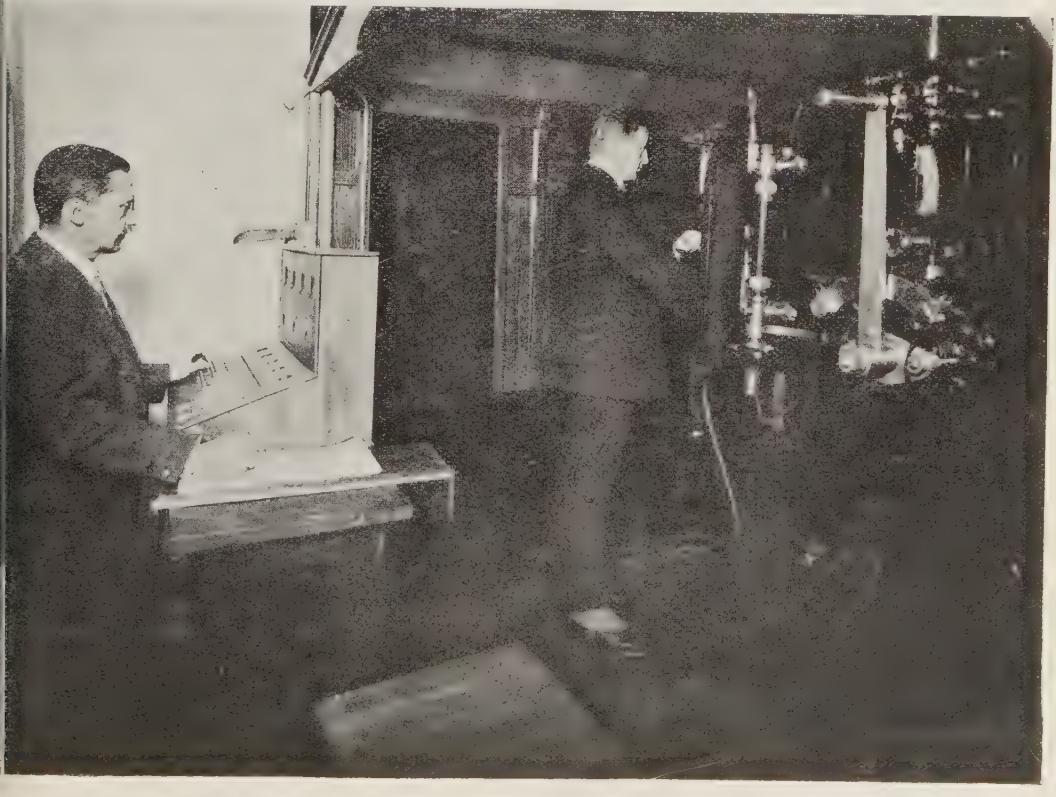

Fig. 5. — View of locomotive cab while a subject is being examined for diffused attention.

Fig. 6. — The six-track apparatus invented by J. Wojciechowski for examining and training pointsmen.

bahn states, speaking generally, that this method gives quicker and more concrete results as regards savings of time and expense. This Administration merely recommends that these appliances be used cautiously in order to avoid, on the one hand, using professional capacity in an unilateral sense and, on another hand, not to neglect practical training suited to the profession in question.

Otherwise, the opinions of professional specialists as regards the psychotechnical apparatus described in German technical literature are also favourable.

The Polish railways have not yet applied psychotechnics to the professional training of employees; certain apparatus used for psychotechnical investigations can, however, be used for professional teaching.

The more important of these appliances are : (1) the right-hand part of the driver's cab, fitted with all the levers and instruments required for driving a locomotive, such an installation enabling the training of young candidates for the post of engine driver to be carried out; 2) the six-track appliance (invented and built at Warsaw) for the exercising and developing of vigilance and diffused attention of candidates for the post of pointsman (see figs. 4 to 6).

In concluding our report we would add that the Polish Ministry of Communications has decided to extend the application of psychotechnical tests, as

Fig. 7. — Plan of the Warsaw psychotechnical laboratory of the Polish Railways.

Legend:

1. Entrance.
2. Manager's office.
3. Ministerial reporter's office.
4. Helper's room.
5. Room for examining engine drivers and firemen.
6. Recording apparatus.
7. Secretary's office.
8. Assistant manager's office.
9. Collective investigation room.
10. Apparatus for measuring reactions.
11. Work test room.
12. Waiting room.

shown by the plan of the Warsaw Railway Laboratory (fig. 7).

SUMMARY.

Our enquiry covered the 7 following countries : Germany, Denmark, Finland, Holland, Norway, Sweden and Poland.

Selection of railway staff by psychotechnical means is only in force in 4 of these countries viz. : Germany, Denmark, Sweden and Poland. It is in Germany and Poland that these new methods have been most extensively applied.

The other countries mentioned above have only started to apply psychotechnical methods.

Those railway officers and men who are submitted to psychotechnical investigations are employed in the train-running and locomotive departments (engine drivers, firemen, station-masters and their assistants, pointsmen and hands employed in the marshalling yards, etc.).

The list of tests imposed on each grade varies from one country to another.

The utility of the system of psychotechnical selection is proved by the fact that concordance between the opinions of the heads of departments and the results of psychotechnical laboratory tests is as high as 90 %. On another hand, the reduced number of accidents on the German and Polish railway sys-

tems, that could be attributed to the staff, proves that the use of psychotechnics is a decided factor in the safety of transportation.

The experience of the German Railways shows that the application of psychotechnical methods to the training of new employees gives very good results, savings in time and money on the training of specialist employees being obtained thereby.

CONCLUSIONS.

Based on the replies received, we may express the following conclusions :

Psychotechnics, considered as an indispensable factor of the scientific selection of railway staff are being applied gradually, although slowly as regards European railways.

It is desirable that the 1937 International Railway Congress should advise all Countries, as well as all Railway Administrations, to support and encourage the future development of this applied science.

A new step forward in the development of psychotechnics will be its application to the professional training of railway servants, thus rendering such training more rapid, more efficacious and less expensive.

The heterogeneity of the methods of examining railway servants in the various States leads us to express the wish that the International Psychotechnical Congress and the International Transport Commission, founded in 1932 at Prague, will undertake the elaboration and definite solution of the problem of creating a single standard method of examining the human factor called upon to collaborate in the operating services of railways, so fraught with responsibility.

It is desirable that the 1937 Congress should express a resolution that Railway Managements in all countries ought to have recourse to psychotechnical tests of staff conjointly with the customary medical examinations, in order that the maximum of transportation safety be achieved.

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JAEGER (K.). — **Kurzschaltzeichnung beim Block.** 2 600 Wörter und Abb.)

1936 **656 .256**

eitschrift für das gesamte Eisenbahn-Sicherungswesen, Nr. 6, 20. Mai, S. 78.

CIECIERSKI. — Eine **Befehlsblockung Art.** (3 400 Vörter und Abb.)

Zeitung des Vereins mitteleuropäischer Eisenbahnverwaltungen. (Berlin.)

1936 **388 (.42) & 625 .4 (.42)**

eitung des Vereins mitteleurop. Eisenbahnverw., Nr. 19, 7. Mai, S. 377.

GRETSCH (R.). — Das **Londoner Verkehrsamt** seit einem Bestehen und die Planungen der nächsten Jahre. 5 300 Wörter und Abb.)

1936 **385 (.494)**

eitung des Vereins mitteleurop. Eisenbahnverw., Nr. 20, 14. Mai, S. 393.

WANNER (F.). — Die **organisatorische und finanzielle Neugestaltung** der Schweizerischen Bundesbahnen. 700 Wörter.)

1936 **656 .2**

eitung des Vereins mitteleurop. Eisenbahnverw., Nr. 20, 14. Mai, S. 397.

Werbeschriften der Eisenbahnen. (3 000 Wörter.)

1936 **625 .23 (.43)**

eitung des Vereins mitteleurop. Eisenbahnverw., Nr. 21, 21 Mai, S. 409.

GERTEIS. — **Schnellverkehr mit doppelstöckigen Einheiten.** (2 700 Wörter und Abb.)

In English.

Engineer. (London.)

1936 **625 .13 (.73)**

ngineer, No. 4189, April 24, p. 438.

A railway **tunnel** with doors. (1 100 words & fig.)

1936 **669 .1**

ngineer, No. 4189, April 24, p. 447.

The Shorter hardening process. (800 words & fig.)

1936 **62. (01 & 621 .43**

ngineer, No. 4190, May 1, p. 456.

Cathode-ray oscillograph for oil engine injection search. (3 600 words & fig.)

1936 **621 .392**

Engineer, No. 4190, May 1, p. 472.

SHERWIN (C. E.). — **Electric welding** in cruiser construction. (5 000 words & fig.)

1936 **627 (.42) & 621 .31 (.42)**

Engineer, No. 4191, May 8, p. 480.

The Lochaber **water power scheme (to be continued).** (2 300 & fig.)

1936 **669 .1 (.52)**

Engineer, No. 4191, May 8, p. 493.

TAJI (Y.). — **Nickel alloys** in Japanese industry. (2 900 words.)

1936 **669 .1**

Engineer, No. 4191, May 8, p. 494.

High-frequency **electric melting furnace** equipment. (3 200 words & fig.)

1936 **627 (.42) & 621 .31 (.42)**

Engineer, No. 4192, May 15, p. 507.

The Lochaber **water power scheme.** (2 700 words & fig.)

1936 **621 .43 (.44) & 656 .25 (.44)**

Engineer, No. 4192, May 15, p. 528.

Sound signal devices on railcars in France. (700 words & fig.)

1936 **669 .1**

The Metallurgist, p. 117, Supplt. to the Engineer, April 24.

Hydrogen as the cause of low elongation and reduction of area of steel. (1 900 words & 7 tables.)

1936 **625 .143.2 & 625 .143.3**

The Metalurgist, p. 120, Supplt. to the Engineer, April 24.

HUMFREY (J. C. W.). — **Internal fissures in rails.** (2 900 words & fig.)

1936 **669 .1**

The Metallurgist, p. 122, Supplt. to the Engineer, April 24.

The influence of alloy additions on the scalding of **steel.** (900 words & fig.)

1936 **62. (01 & 669 .1**

The Metallurgist, p. 125, Supplt. to the Engineer, April 24.

Metals under high pressures. (1 700 words & 1 table.)

Engineering. (London.)

1936 **621 .43**

Engineering, No. 3668, May 1, p. 469.

GLAISTER (E.). — The measurement of ignition delay in **oil-engines.** (2 900 words & fig.)

1936 **621 .335 (.73)**

Engineering, No. 3668, May 1, p. 474.

Electric locomotives for the Pennsylvania Railroad. (2 100 words & fig.)

1936 **621.** (06 (.42) & **621** .392 (.42)
Engineering, No. 3668, May 1, p. 486.
Welding research. (2 400 words.)

1936 **621.** (06 (.42) & **621** .392 (.42)
Engineering, No. 3668, May 1, p. 492.
Welding research. (Second report of the welding Research Committee, read before the Institution of Mechanical Engineers on April 24, 1936. (Abridged.) (2 400 words, 2 tables & fig.)

1936 **62.** (01 & **669**
Engineering, No. 3669, May 8, p. 504.
Fault detection by magnetic methods. (1 600 words & fig.)

1936 **621** .392
Engineering, No. 3670, May 15, p. 544.
Welding research. (3 700 words & fig.)

Engineering News-Record. (New York.)

1936 **625** .4 (.47)
Engineering News-Record, No. 15, April 9, p. 515.
GUTMANN (I.). — The Moscow **subway.** (5 600 words & fig.)

1936 **625** .4 (.47) & **656** .215 (.47)
Engineering News-Record, No. 15, April 9, p. 521.
PINCO (C. N.). — **Highlights of Moscow subways.** (2 700 words & fig.)

1936 **55, 62.** (01 & **721** .1
Engineering News-Record, No. 15, April 9, p. 533.
KNAPPEN (Th. T.) & PHILIPPE (R. R.). — **Practical soil mechanics** at Muskingum — II. (3 000 words & fig.)

1936 **624** .63 (.47)
Engineering News-Record, No. 16, April 16, p. 563.
CHLEBNIKOV (E. L.). — **Nailed timber centering for concrete-arch bridges in Russia.** (1 100 words & fig.)

1936 **55, 62.** (01 & **721** .1
Engineering News-Record, No. 17, April 23, p. 595.
KNAPPEN (Th. T.) & PHILIPPE (Rob. R.). — **Practical soil mechanics** at Muskingum — III. — Resisting strength of foundations. (3 600 words & fig.)

1936 **624** .63 (.73)
Engineering News-Record, No. 17, April 23, p. 604.
BENESCH (A.) & MORGAN (C. E.). — Designing **concrete girder bridges** for continuity. (1 800 words & fig.)

1936 **624** .51 (.73)
Engineering News-Record, No. 19, May 7, p. 656.
PURCELL (C. H.), ANDREW (Ch. E.) & WOODRUFF (G. B.). — **Cable spinning** on the Bay Bridge. (5 800 words & fig.)

1936 **625** .13 (.73)
Engineering News-Record, No. 19, May 7, p. 661.
RANKIN (C. R.). — Novel high pressure grouting methods seal **fissures in wet tunnel.** (2 100 words & fig.)

1936 **55, 62.** (01 & **721** .1
Engineering News-Record, No. 19, May 7, p. 666.
KNAPPEN (Th. T.) & PHILIPPE (R. R.). — **Practical soil mechanics** at Muskingum — I. (2 800 words & fig.)

1936 **624** .8 (.73)
Engineering News-Record, No. 19, May 7, p. 671.
Lift span erected by new procedure. (1 500 words & fig.)

Great Western Railway Magazine. (London.)

1936 **621** .9 (.42) & **625** .26 (.42)
Great Western Ry. Magazine, May, p. 213.
A 190-feet carriage-making machine at the G. W. R. Swindon works. (1 700 words & fig.)

Journal, Institution of Engineers, Australia. (Sydney, N. S. W.)

1936 **627** & **62**
Journal, Institut. of Engineers, Australia, March, p. 8
ROBIN (R. C.). — **The discharge of rectangular culverts.** (5 200 words, fig. & 3 tables.)

1936 **624** .8 (.944
Journal, Institut. of Engineers, Australia, March, p. 9
DENNIS (S.). — **Bridge** over Parramatta River at Ryde, New South Wales. (12 000 words, 1 table & fig

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Journal, Institute of Transport. (London.)

1936 **656** .2
Journal, Institute of Transport, May, p. 366.
WOOD (W. V.). — **The problem of railway charges.** Paper read in London on April 6th, 1936. (Discussion) (18 000 words.)

1936 **6**
Journal, Institute of Transport, May, p. 385.
BELL (R.). — **Transports developments in 193** Lecture delivered in London on April 21st, 1936. (5 7 words.)

1936 **347** .763 (.6
Journal, Institute of Transport, May, p. 391.
EMMETT (E.). — **Post-Union transport law.** (5 6 words.)

ournal, Western Society of Engineers. (Chicago.)

1936 **621 .392 & 721 .9**

ournal, Western Soc. of Engineers, February, p. 8.

WILSON (W. M.). — Present status of **structural** elding. (Paper presented before the Western Society f Engineers, December 9, 1935.) (3 800 words & fig.)

Modern Transport. (London.)

1936 **625 .232 (.43)**

lodern Transport, No. 893, April 25, p. 3.

German double-deck steam train unit. (1 200 words fig.)

1936 **625 .25**

lodern Transport, No. 893, April 25, p. 5.

Retardation on railways. — Use of brake testing quipment. (2 200 words & fig.)

1936 **656 .253 (.42)**

lodern Transport, No. 894, May 2, p. 3.

Largest station **power signalling** on L. N. E. R. (1 200 ords & fig.)

1936 **621 .131.2**

odern Transport, No. 894, May 2, p. 4.

Design of **steam locomotives.** Reduction of weight. 400 words.)

1936 **621 .43 (.54)**

odern Transport, No. 894, May 2, p. 5.

Oil-engined shunting locomotives. New units for M. S. Ry. and India. (1 700 words & fig.)

1936 **656 .1 & 656 .23**

odern Transport, No. 894, May 2, p. 8.

Railway charges and road competition. Problem of e ancillary user. (2 500 words.)

1936 **621 .33 (∞)**

odern Transport, No. 894, May 2, p. 9.

Main line railway electrification. Progress throughout e world. (1 100 words.)

1936 **621 .335 (.436) & 621 .338 (.436)**

odern Transport, No. 895, May 9, p. 3.

STRAUSS (F.). — **Electric railcars and light locotives.** Two new models introduced in Austria. (1 200 ords & fig.)

1936 **656 .1 & 656 .23**

odern Transport, No. 895, May 9, p. 6.

Railway charges and road competition. — « What e traffic will bear » in international trade. (2 200 ords.)

1936 **621 .33 (∞)**

odern Transport, No. 895, May 9, p. 7.

Main line railway electrification. Progress through- t the world. (Contd.) (2 100 words.)

1936 **621 .138.5 (.42)**

Modern Transport, No. 896, May 16, p. 9.

Modern methods of locomotive repair. The processing system at Crewe Works, London Midland & Scottish Railway. (2 500 words & fig.)

1936 **656 .212 (.42)**

Modern Transport, No. 896, May 16, p. 11.

G. W. R. freight facilities in the Black Country. (2 000 words & fig.)

1936 **621 .43 (.41)**

Modern Transport, No. 896, May 16, p. 15.

Oil-engined railcars for Belfast suburban services. (2 300 words & fig.)

Railway Age. (New York.)

1936 **625 .14**

Railway Age, No. 14, April 4, p. 570.

FARIES (R.). — **What of the track ?** (3 600 words.)

1936 **625 .231 (.73)**

Railway Age, No. 14, April 4, p. 575.

Reading Company builds 25 cabooses. (1 500 words & fig.)

1936 **656 .222.1 (∞)**

Railway Age, No. 14, April 4, p. 583.

American trains hold **world speed records.** (1 600 words & tables.)

1936 **621 .43 (.73)**

Railway Age, No. 15, April 11, p. 608.

Illinois Central **high-speed train** goes on extensive tour. (5 000 words, tables & fig.)

1936 **625 .122 (.73) & 656 .284 (.73)**

Railway Age, No. 15, April 11, p. 618.

Great Northern combats severe **slide conditions.** (2 600 words & fig.)

1936 **621 .43 (.73)**

Railway Age, No. 16, April 18, p. 647.

Illinois Central **1 800-hp. diesel-electric transfer locomotive.** (2 500 words, tables & fig.)

1935 **385 .1 (.73) & 385 .5 (.73)**

Railway Age, No. 16, April 18, p. 655.

EASTMAN (J. B.). — **The future of transportation.** (3 200 words.)

1935 **621 .43 (.73)**

Railway Age, No. 16, April 18, p. 659.

BUDD (R.). — **A million miles of new railway travel.** (3 000 words & fig.)

1936 **656 .262 (.73)**

Railway Age, No. 17, April 25, p. 680.

Unique hotel facilities built at Grand Canyon by Atchison, Topeka & Santa Fe. (3 000 words & fig.)

1936 **385. (072 (.73) & 625 .14 (.73)**
Railway Age, No. 17, April 25, p. 685.
A journal bearing laboratory. (1 200 words & fig.)

1936 **656 .261 (.73)**
Railway Age, No. 17, April 25, p. 687.
New York Railroad Club sponsors forum on **storedoor service.** (4 000 words.)

1936 **656 .1 (.73)**
Railway Age, No. 17, April 25, p. 692.
National trailways begins operations. (2 400 words & fig.)

1936 **656 .1 (.73)**
Railway Age, No. 17, April 25, p. 697.
All Delaware Valley **passengers and L. C. L. handled by highway.** (1 400 words & fig.)

Railway Engineering and Maintenance. (Chicago.)

1936 **656 .284 (.73)**
Railway Engineering & Maintenance, April, p. 226.
Floods ravage railways in the East. (3 800 words & fig.)

1936 **625 .173 (.73)**
Railway Engineering & Maintenance, April, p. 230.
Special gangs reduce cost of **tie renewals** on the Chicago, Milwaukee, St. Paul & Pacific. (Large gangs which can be fully mechanised.) (3 700 words & fig.)

1936 **625 .142.2**
Railway Engineering & Maintenance, April, p. 234.
SCHEFFERT (T. C.). — **What is blue stain in lumber ?** (900 words.)

1936 **625 .13**
Railway Engineering & Maintenance, April, p. 235.
Taking up **wear on bridge pins.** (1 000 words & fig.)

1936 **625 .13 & 721 .2**
Railway Engineering & Maintenance, April, p. 237.
Metal cribbing saves failed tail wall. (500 words & fig.)

1936 **625 .173 (.73)**
Railway Engineering & Maintenance, April, p. 238.
Branch line problem (maintenance) solved by longer sections. (Fort Worth & Denver City.) (2 500 words & fig.)

1936 **625 .113 (.73)**
Railway Engineering & Maintenance, April, p. 241.
WILLIS (R. W.). — **Simplifying curve calculations.** (1 700 words & fig.)

Railway Gazette. (London.)

1936 **625 .1 (.56)**
Railway Gazette, No. 17, April 24, p. 792.
Proposed railway improvements in Palestine. (2 600 words & fig.)

1936 **625 .232 (.44)**
Railway Gazette, No. 17, April 24, p. 795.
CHATEL & YOLLANT. — **New articulated light-metal coaches** of the Northern Ry. of France. (2 300 words & fig.)

1936 **625 .244**
Railway Gazette, No. 17, April 24, p. 800.
New refrigerated four-wheel wagon. (500 words & fig.)

1936 **625 .13**
Railway Gazette, No. 18, May 1, p. 859.
The repair and reconstruction of metal footbridges. (1 500 words & fig.)

1936 **656 .254 (.43)**
Railway Gazette, No. 18, May 1, p. 861.
Automatic train control in Germany. (1 600 words & fig.)

1936 **625 .144.4 (.82) & 625 .172 (.82)**
Railway Gazette, No. 18, May 1, p. 864.
WILLIAMSON (G. N.). — Measured **shovel packing** in Argentina. (1 300 words & fig.)

1936 **621 .132.3 (.73)**
Railway Gazette, No. 18, May 1, p. 867.
New streamlined locomotive for the Pennsylvania Railroad. (800 words & fig.)

1936 **621 .9 (.42)**
Railway Gazette, No. 18, May 1, p. 869.
Some machine tools at Crewe works, L. M. S. R. (600 words & fig.)

1936 **621 .132.8**
Railway Gazette, No. 19, May 8, p. 903.
Increasing the power of steam locomotives. — The Velox system developed by Brown Boveri & Company (800 words & fig.)

1936 **656 .222.1 (.493)**
Railway Gazette, No. 19, May 8, p. 905.
Belgian locomotive performance. (3 400 words & fig.)

1936 **656 .26**
Railway Gazette, No. 19, May 8, p. 913.
Advantages of liquid bulk haulage. The organisation of Pickfords tank wagon fleet. (1 300 words & fig.)

1936 **625 .143.5 (.43)**
Railway Gazette, No. 20, May 15, p. 943.
Behaviour of screw fastenings in wooden sleepers (2 700 words & fig.)

1936 **385.** (091 (.56)
Railway Gazette, No. 20, May 15, p. 946.
The Iraq Railways. (4 200 words & a map.)

1936 **625 .232** (.51)
Railway Gazette, No. 20, May 15, p. 950.
A Kowloon-Canton Railway **buffet car.** (450 words & fig.)

1936 **621 .132.3** (.51) & **621 .132.5** (.51)
Railway Gazette, No. 20, May 15, p. 951.
New 2-8-2 locomotives for China. (600 words & fig.)

1936 **625 .232** (.41)
Railway Gazette, No. 20, May 15, p. 953.
New buffet cars, G. N. R. (Ireland.) (700 words & fig.)

1936 **385 .113** (.42)
Railway Gazette, April 24, Supplt., p. 817.
Financial and operating results of the British Group Railways in 1935. (6 000 words & 28 tables.)

1936 **621 .43** (.82)
Diesel Ry. Traction, p. 970, Supplt. to Ry. Gazette, May 15.
Large scale introduction of **railcars** in Argentina. (2 000 words & fig.)

1936 **621 .43** & **621 .8**
Diesel Ry. Traction, p. 974, Supplt. to Ry. Gazette, May 15.
MIALL (S.). — **Transmissions for Diesel locomotives and railcars.** The Minerva presynchronising gearbox. (1 300 words & fig.)

1936 **625 .253**
Diesel Ry. Traction, p. 976, Supplt. to Ry. Gazette, May 15.
A retardation controller for high speed braking. (300 words & fig.)

1936 **621 .43** (.54)
Diesel Ry. Traction, p. 977, Supplt. to Ry. Gazette, May 15.
Indian broad-gauge shunting locomotive. (400 words & fig.)

1936 **621 .43** (.73) & **625 .232** (.73)
Diesel Ry. Traction, p. 978, Supplt. to Ry. Gazette, May 15.
A high-speed train and big locomotive for the Illinois Central Railroad. (1 900 words & fig.)

1936 **621 .43** (.497.1)
Diesel Ry. Traction, p. 983, Supplt. to Ry. Gazette, May 15.
Half a dozen **Diesel railcars** for Jugoslavia. (450 words & fig.)

1936 **621 .33** (∞)
Electric Ry. Traction, p. 886, Supplt. to the Ry. Gazette, May 1.
KAAN (E. R.). — **Main-line electrification** throughout the world. (5 200 words & fig.)

Railway Magazine. (London.)

1936 **656 .1** (.41)
Railway Magazine, May, p. 313.
JACKSON (W. N.). — **Replacing a railway.** — Londonderry & Lough Swilly System. (3 300 words & fig.)

1936 **621 .132.1** (.41)
Railway Magazine, May, p. 345.
Locomotive. No. 1. — The Irish Railways. (900 words & fig.)

1936 **385.** (09 .1 (.41)
Railway Magazine, May, p. 347.
NOCK (O. S.). — **The N. C. C. Section of the L. M. S. R.** (3 500 words & fig.)

Railway Mechanical Engineer. (Philadelphia.)

1936 **621 .13** (01 (.73) & **621 .132.3** (.73)
Railway Mechanical Engineer, April, p. 135.
Pennsylvania **streamline steam locomotive.** (1 000 words & fig.)

1936 **621 .135.2** (.73)
Railway Mechanical Engineer, April, p. 136.
Roller-bearing journal box with lateral-motion. (1 200 words & fig.)

1936 **621 .131.1**
Railway Mechanical Engineer, April, p. 138.
WARNER (P. T.). — **Horse-power and grate area.** (3 000 words, 9 tables & fig.)

1936 **625 .25**
Railway Mechanical Engineer, April, p. 142.
SILLCOX (L. K.). — **Brakes for modern high speed trains.** — Improvements made in brakes to meet new conditions. (3 700 words & fig.)

1936 **656 .222.1**
Railway Mechanical Engineer, April, p. 145.
DE BELL (G. W.). — **Effect of natural winds on air drag.** (1 100 words & fig.)

1936 **621 .43** (.73)
Railway Mechanical Engineer, April, p. 147.
Diesel-electric freight locomotive. (1 500 words & fig.)

1936 **621 .133.3** & **621 .392**
Railway Mechanical Engineer, April, p. 151.
Some notes on **boiler welding.** (1 100 words.)

1936 **625 .245** (.73)
Railway Mechanical Engineer, April, p. 156.
Four weeks to rebuild 100 Reading **automobile cars.** (1 300 words & fig.)

1936 **625 .236** (.73)
Railway Mechanical Engineer, April, p. 161.
Passenger car sash washing machine. (500 words & fig.)

1936 **625 .26 (.73)**
Railway Mechanical Engineer, April, p. 165.
NEALEY (J. B.). — **Spring manufacture** at Altoona shops. (1 000 words & fig.)

Railway Signaling. (Chicago.)

1936 **656 .259 (.73)**
Railway Signaling, April, p. 193.
Yard entrance in Montreal remotely controlled. (2 400 words & fig.)

1936 **656 .259 (.73)**
Railway Signaling, April, p. 196.
Remote control replaces a mechanical interlocking on the Louisville & Nashville. (2 800 words & fig.)

1936 **625 .162 (.73)**
Railway Signaling, April, p. 201.
Automatic crossing gates installed on the Louisville & Nashville. (2 700 words & fig.)

1936 **625 .162 (.73) & 656 .259 (.73)**
Railway Signaling, April, p. 205.
CORREY (C. L.). — **Crossing signal** at Erie, Pa. (1 800 words & fig.)

1936 **625 .162 (.73)**
Railway Signaling, April, p. 207.
Automatic gates tested by Burlington. (5 200 words, tables & fig.)

The Locomotive. (London.)

1936 **621 .132.1 (.71)**
The Locomotive, April 15, p. 100.
SOOLE (G. H.). — **Locomotive** of the Mountain Section, Canadian Pacific Ry. (2 400 words & fig.)

1936 **621 .133.7**
The Locomotive, April 15, p. 104.
Developments in **boiler feeding.** (1 200 words & fig.)

1936 **621 .132.8 (.65)**
The Locomotive, April 15, p. 109.
New Beyer-Garratt locomotive, Algerian Railways. (2 500 words & fig.)

1936 **625 .1 (.66)**
The Locomotive, April 15, p. 118.
A mineral railway in Sierra Leone. (1 100 words & fig.)

1936 **621 .43 (.434)**
The Locomotive, April 15, p. 120.
Diesel-electric railcars, Czechoslovakian State Railways. (600 words & fig.)

1936 **621 .43 (.43) & 656 .222.1 (.43)**
The Locomotive, April 15, p. 121.
The Berlin-Cologne « Flyer ». (1 200 words & fig.)

1936 **625 .234**
The Locomotive, April 15, p. 130.
Air-cooled coach for the French Colonial Railways (550 words.)

The Oil Engine. (London.)

1936 **621 .43**
The Oil Engine, March, p. 344.
Diesel express main line trains (Denmark). — Four 1 100-b.h.p. units ordered. (600 words & fig.)

1936 **621 .43 (.67)**
The Oil Engine, March, p. 350.
950 b.h.p. diesel locomotives. — Pressure-charged engines for two Congo-Ocean Railway locomotives. (80 words & fig.)

1936 **621 .43**
The Oil Engine, March, p. 355.
Railcar progress and prospects. (1 600 words & fig.)

1936 **621 .43 (.42)**
The Oil Engine, March, p. 356.
An L. M. S. Railway **diesel-electric locomotive.** (1 600 words & fig.)

1936 **621 .43 (.73)**
The Oil Engine, March, p. 362.
MANN (Ch. F. A.). — America's finest **diesel train** (Baltimore & Ohio Railroad.) — Two 900 b.h.p. Winton engines in a locomotive hauling a special train designed for diesel and steam power comparison. (1 000 words & fig.)

1936 **621 .43 (.44)**
The Oil Engine, April, p. 375.
4 000-b.h.p. locomotives for Paris-Riviera service to be completed this year. (Maximum 80 m.p.h.) (90 words & fig.)

1936 **621 .43 (.44)**
The Oil Engine, April, p. 396.
Diesel shunting locomotives for home and overseas (Armstrong-Withworth oil-electric locomotives for the L. M. S. R. and the B. B. & C. I. Ry. (1 300 words & fig.)

1936 **621 .43 (.493)**
The Oil Engine, May, p. 4.
Belgium's new Diesel express train service. (500 words & fig.)

1936 **621 .43**
The Oil Engine, May, p. 27.
The merits of horizontal and vertical engines. (700 words.)

1936 **621 .43 (.73)**
The Oil Engine, May, p. 28.
MANN (Ch. F. A.). — Latest American **Diesel train development.** (1 200 words & fig.)

Transit Journal. (New York.)

1936 **621 .336 (.73)**

Transit Journal, April, p. 110.

MURPHY (H. S.). — **Wire breaks becoming a rarity.** (600 words & fig.)

1936 **625 .614 (.73) & 625 .62 (.73)**

Transit Journal, April, p. 113.

Brooklyn tries **light concrete track.** (600 words & fig.)

In Spanish.

Anales de la Asociación de Antiguos Alumnos del I. C. A. I. (Madrid.)

1936 **621 .335**

Anales de la Asociación de Antiguos Alumnos del I. C. A. I., abril, p. 187.

VAZQUEZ LAZARO (P.). — El control eléctrico en **las locomotoras y automotores de corriente continua.** (2 600 palabras & fig.)

Los Transportes. (Madrid.)

1936 **656 .225 (.460) & 656 .261 (.460)**

Los transportes, N° 423, 1 mayo, p. 97.

Transportes especiales en « containers » de propiedad particular. (1 400 palabras.)

Revista de Ingeniería Industrial. (Madrid.)

1936 **625 .213**

Revista de Ingeniería industrial, abril, p. 86.

LAFFITTE (C.). — El funcionamiento de la **suspensión de vehiculos.** (1 800 palabras & fig.)

Revista del Consejo Administrativo de los Ferrocarriles Nacionales de la República de Colombia. (Bogotá.)

1936 **625 .3**

Revista del C. Ad. de los FF. CC. Nac. de la República de Colombia, enero-febrero, p. 6.

Consideraciones generales sobre el **uso de la cremallera.** (10 500 palabras & fig.)

Revista de Obras Públicas. (Madrid.)

1936 **624 .63 (.460)**

Revista de Obras Públicas, N° 10, 15 de mayo, p. 185.

VILLALBA GRANDA (C.). — El **puente** sobre el río Guadalhorce, en Pizarra, Málaga. (2 400 palabras & fig.)

1936 **62. (01**

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1936 **62. (01 & 6**

Zeitsch. des Ver. deutsch. Ing.. Nr. 24, 13. Ju S. 741.

WIDEMANN (M.). — **Zerstörungsfreie Prüfu schwermetallischer Werkstücke** mit ultrakurzwelli Röntgenstrahlung. (3 000 Wörter und Abb.)

1936 **669**

Zeitsch. des Ver. deutsch. Ing., Nr. 24, 13. Ju S. 751.

SCHRERER (R.) und ZIELER (W.). — **Fehler Stahl.** (3 700 Wörter und Abb.)

1936 **62. (**

Zeitsch. des Ver. deutsch. Ing., Nr. 24, 13. Ju S. 755.

NITSCHE (R.). — **Prüfung von Fertigstücken** Pressstoff auf mechanische Stoffeigenschaften. (2 Wörter und Abb.)

1936 **621**

Zeitsch. des Ver. deutsch. Ing., Nr. 25, 20. Ju S. 769.

SCHMIDT (F. A. F.). — Vergleichende Untersuch gen der **Verbrennungs- und Arbeitsvorgänge an Mo ren** verschiedener Arbeitsverfahren. (6 600 Wör und Abb.)

1936 **691**
itsch. des Ver. deutsch. Ing., Nr. 25, 20. Juni, S. 781.
KAPPLER (Fr.). — Neuzeitliche **Entrostungsverhren.** (2 100 Wörter und Abb.)

Zeitschrift für das gesamte Eisenbahn-Sicherungswesen. (Berlin.)

1936 **656 .254**
itschr. für das gesamte Eisenb.-Sicherungsw., Nr. 8, 10. Juni, S. 85.
KRAUSKOPF (L.). — Neuere Entwicklung auf dem biete der **Zugbeeinflussung.** (4 300 Wörter und Abb.) ortsetzung folgt.)

Zeitung des Vereins mitteleuropäischer Eisenbahnverwaltungen. (Berlin.)

1936 **625 .163 (.436)**
itung des Vereins mitteleurop. Eisenbahnverw., Nr. 23, 4. Juni, S. 447.
SCHOBER (O.). — **Elementarereignisse und deren kämpfung** auf der Arlbergbahn. (3 700 Wörter und b.)

1936 **385 .1 (.492)**
itung des Vereins mitteleurop. Eisenbahnverw., Nr. 23, S. 454.
TISSOT VAN PATOT (J. P. B.). — Die **Ersparnisassnahmen** bei den Niederländischen Eisenbahnen seit 21. (5 100 Wörter und Abb.)

1936 **656 (.438)**
itung des Vereins mitteleurop. Eisenbahnverw., Nr. 24, 11 Juni, S. 467.
SERAPHIN (P. H.). — **Eisenbahn, Binnenschiffahrt d Kraftwagen** in Polen. (4 200 Wörter und Abb.)

1936 **621 .43 (.436)**
itung des Vereins mitteleurop. Eisenbahnverw., Nr. 24, 11. Juni, S. 473.
PREITNER (H.). — Der neue **Diesel-elektrische iebwagen** der Österreichischen Bundesbahnen. (1 900 örter und Abb.)

In English.

Engineer. (London.)

1936 **669 .1 (06 (.42)**
gineer, No. 4193, May 22, p. 536.
The embrittlement of **high-tensile alloys** at elevated nperatures, by W. E. GOODRICH. — Creep and owth of cast iron at elevated temperatures, by H. J. PSELL, M. L. BECKER and C. G. CONWAY. — ernal stresses in spring steel, by M. L. BECKER d C. E. PHILLIPS. (5 900 words and fig.)

1936 **621 .43 (.44)**
Engineer, No. 4193, May 22, p. 541.
A producer **gas railcar.** (900 words and fig.)

1936 **621 .132.3 (.942)**
Engineer, No. 4193, May 22, p. 552.
An Australian « **streamlined** » **locomotive.** (200 words and fig.)

1936 **62. (01 & 669 .1**
Engineer, No. 4193, May 22, p. 553.
HANKINS (G. A.), BECKER (M. L.) and MILLS (H. R.). — Surface conditions and the **fatigue resistance of steels.** (3 000 words and 5 tables.)

1936 **669 .1 (06 (.42)**
Engineer, No. 4194, May 29, p. 563.
The Iron and Steel Institute, No. III. — Factors influencing the rate of **attack of mild steels by typical weak acid media,** by T. P. HOAR & D. HAVENHAND. (2 000 words.)

1936 **656 .281 (.42)**
Engineer, No. 4194, May 29, p. 581.
The Ken viaduct derailment. (3 800 words and fig.)

1936 **621 .43 & 621 .8**
Engineer, No. 4195, June 5, p. 604.
An automatic clutch for railcars. (600 words and fig.)

1936 **665 .882 (06**
Engineer, No .4197, June 19, p. 647; Engineer, No. 4198, June 26, p. 689.
The Twelfth International Acetylene Congress. (6 400 words.)

1936 **385. (092**
Engineer, No. 4197, June 19, p. 651.
A great locomotive engineer : Alfred de Glehn. (1 200 words.)

1936 **62. (01**
Engineer, No. 4197, June 19, p. 653.
Theory of fracture. (Read by Dr. HAIGH at the Royal Society Debate on June 11th 1936.) (2 000 words.)

1936 **725 .56 (.42)**
Engineer, No. 4198, June 26, p. 666.
60 000 ton grain silo at Liverpool. (2 500 words and fig.)

1936 **62. (01 & 669**
Engineer, No 4198, June 26, p. 669.
QUIRMEY (H.). — Further tests on the effect of **time in testing.** (3 300 words and fig.)

1936 **621 .132.3 (.42)**
Engineer, No. 4198, June 26, p. 676.
The « Green Arrow » L. N. E. R. **three-cylinder 2-6-2 locomotive.** (900 words and fig.)

1936 **621 .132.5 (.54)**
Engineer, No. 4198, June 26, p. 686.
Metre-gauge locomotive for the Assam Bengal Railway. (600 words and fig.)

1936 **62. (01**
Engineer, No. 4198, June 26, p. 687.
A direct-reading hardness testing machine. (1 100 words and fig.)

1936 **625 .143.2 & 625 .143.3**
The Metallurgist, p. 137, Supplt. to the Engineer, June 26.
HUMFREY (J. C. W.). — **Internal fissures in rails,** No. II. — The Sandberg Oven process. (2 600 words and fig.)

1936 **62. (01**
The Metallurgist, p. 141, Supplt. to the Engineer, June 26.
Impact torsion tests. (600 words and fig.)

Engineering. (London.)

1936 **669 .1 (06 (.42)**
Engineering, No. 3671, May 22, p. 564.
Embrittlement of high-tensile alloy steels, by Mr. W. E. GOODRICH. — **Creep and growth of five cast irons,** by Mr. H. J. TAPSELL. — **Fatigue resistance of spring steels,** by Dr. G. A. HANKINS, Mr. M. L. BECKER & Mr. H. R. MILLS. — **Internal stresses and their effect on the fatigue resistance of spring steels,** by Dr. M. L. BECKER & Mr. C. E. PHILLIPS. (4 800 words and 1 table.)

1936 **62. (01 & 624 .63**
Engineering, No. 3671, May 22, p. 566.
Time yield and deformation stresses in a **reinforced-concrete arch bridge.** (600 words.)

1936 **621 .116**
Engineering, No. 3671, May 22, p. 573.
SCHROEDER (W. C.) & BERK (A. A.). — **Action of solutions of sodium silicate and sodium hydroxide at 250 deg. C. on steel under stress.** (2 600 words and 4 tables.)

1936 **665 .882 (06**
Engineering, No. 3674, June 12, p. 646; No. 3675, June 19, p. 673.
International Congress of Acetylene, Oxy-acetylene welding and Allied industries. (11 000 words.) (To be continued.)

1936 **669 .1**
Engineering, No. 3674, June 12, p. 651.
GOODRICH (W. E.). — **The embrittlement of high-tensile alloy steels at elevated temperatures.** (3 600 words, fig. and tables.)

1936 **62. (01 & 621 .89**
Engineering, No. 3675, June 19, p. 659.
STEINER (L.). — The viscometrical inspection of **lubricating oil in service.** (2 700 words and fig.)

1936 **62. (06 (.42**
Engineering, No. 3675, June 19, p. 660.
The converzazione of the Institution of Civil Engineers. (3 600 words and fig.)

1936 **625 .143.2 (.42**
Engineering, No 3675, June 19, p. 666.
The testing of sorbitic steel rails. (2 200 words, 3 tables and fig.)

1936 **662. (.42 + .73**
Engineering, No. 3675, June 19, p. 671.
British and American fuel practice. (2 600 words

1936 **385. (072 (.49**
Engineering, No. 3676, June 26, p. 685.
The aerodynamics laboratory of the Swiss Federal Institute of Technology, Zürich. (2 300 words and fig

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1936 **656 .1 (.4**
Engineering, No. 3676, June 26, p. 695.
Tramcar-carrying trailer. (1 000 words and fig.)

1936 **621 .132.3 (.4**
Engineering, No. 3676, June 26, p. 704.
2-6-2 type locomotives for the London and North Eastern Railway. (900 words and fig.)

1936 **62. (01 & 721**
Engineering, No. 3676, June 26, p. 709.
BEAUFOY (L. A.). — **Deformeter analysis of welded rigid-arch building.** (3 000 words, 4 tables and fig.)

1936 **621 .95 (.4**
Engineering, No. 3676, June 26, p. 712.
Duplex drilling machine for flanged rails. (400 words and fig.)

Engineering News-Record. (New York.)

1936 **624 .51 (.**
Engineering News-Record, No. 18, April 30, p. 617
JONES (Ch. M.). — **Largest and longest bridge cables spun at new record rate.** (3 500 words and f

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1936 **624**
Engineering News-Record, No. 18, April 30, p. 62
MEEM (J. C.). — **Design and theory of the discontinuous-web girder.** (1 100 words and fig.)

1936 **621 .392 (.**
Engineering News-Record, No. 18, April 30, p. 62
JEFFERSON (T. B.). — **Welding** at Fort Peck k equipment at work. (3 400 words and fig.)

1936 **624 .2 & 72**
Engineering News-Record, No. 18, April 30, p. 63
ECKLES (H. E.). — Taking account of axial c pression in **concrete beam design.** — Developmen a design method for a condition which when ign as is common practice results in a deficiency in r forcement and an excessive beam depth. (2 200 w and fig.)

1936 **55 & 721 .1**
gineering News-Record, No. 20, May 14, p. 690.
TERZAGHI (K.). — **Arching in sands.** (3 300 words l fig.)

1936 **624 .63**
gineering News-Record, No. 20, May 14, p. 693.
WHYTE (C. R.). — Temperatures in concrete hes. (1 400 words and fig.)

1936 **621 .392 (.4) & 624 (.4)**
gineering News-Record, No. 20, May 14, p. 703.
LA MOTTE GROVER. — Foreign countries lead U. S. **welded bridges.** (6 200 words and fig.)

1936 **62. (01 & 721 .1**
gineering News-Record, No. 21, May 21, p. 731.
DEIGNAN (J. E.). — **Measuring bed rock action** er Tygart dam. (700 words and fig.)

1936 **55, 62. (01 & 721 .1**
gineering News-Record, No. 21, May 21, p. 732.
KILBOY (G.). — **Improved soil testing methods** 00 words and fig.)

1936 **621 .133.7 (.73)**
gineering News-Record, No. 22, May 28, p. 781.
DAVIS (D. E.) & CAMPBELL (J. T.). — **Zeolite** l coke filters) **removes manganese.** (2 400 words fig.)

1936 **621 .133.7 (.73)**
gineering News-Record, No. 22, May 28, p. 783.
NAGTBORG (H.). — **Mixing experiments (in water** tment). (3 300 words and fig.)

1936 **62. (01 & 721 .1**
gineering News-Record, No. 23, June 4, p. 804.
ew soil sampler for deep tests. (1 600 words and

1936 **624 .51 (.73)**
gineering News-Record, No. 23, June 4, p. 811.
HANLEY (L. B.) & HARRIS (S.). — **Rapid transit** ns across **Philadelphia-Camden Bridge.** (3 000 words fig.)

Journal, Institution of Engineers, Australia. (Sydney, N. S. W.)

1936 **625 .62**
nal, Institut. of Eng., Australia, April, p. 137.
MAC LEAN (F. N.). — **Tramcar design.** (Discussion.) 0 words.)

Journal, Institute of Transport. (London.)

1936 **385 .2 (.44)**
nal, Institute of Transport, June, p. 418.
VIN (L. P.). — **Mechanical traction** on the French rways. (13 500 words and fig.)

1936 **656 (.94)**
Journal, Institute of Transport, June, p. 438.
BLAND (F. A.). — An administrative approach to **Australian transport problems.** Abstract of lecture delivered before the New South Wales Centre at Sydney on July 30th, 1935. (5 000 words.)

1936 **656 (.42)**
Journal, Institute of Transport, June, p. 444.
LAMB (D. R.). — **The outlook for transport.** (5 800 words.)

Mechanical Engineering. (New York.)

1936 **621 .39 & 621 .43**
Mechanical Engineering, May, p. 283
SAWYER (H. T.). — **An indicator for high-speed engines.** (2 000 words and fig.)

1936 **621. (06 (.73) & 621 .43 (.73)**
Mechanical Engineering, May, p. 286.
VINCENT (E. T.). — **Design of light-weight compression-ignition engines.** (5 000 words, 3 tables and fig.)

1936 **665 .882**
Mechanical Engineering, May, p. 293.
PLINKE (G. W.). — **Gas welding of class-1 pressure vessels.** (3 000 words and fig.)

1936 **613**
Mechanical Engineering, May, p. 298.
HAGGARD (H. W.). — Work and fatigue. — The maintenance of **physiological efficiency in industry.** (2 000 words, 3 tables and fig.)

1936 **621. (06 (.73) & 621 .116 (.73)**
Mechanical Engineering, May, p. 321.
A. S. M. E. Boiler Code. (Interpretations.) — Revisions and Addenda to boiler construction code. (6 000 words and fig.)

1936 **625 .2 & 656 .221**
Mechanical Engineering, June, p. 355.
SILLCOX (L. K.). — **Streamlining.** — Facts and fancies. (3 700 words and fig.)

1936 **62. (01, 665 .882 & 669 .1**
Mechanical Engineering, June, p. 363.
ZIMMERMAN (J. H.). — **Flame-cutting steel plate.** (2 300 words, 5 tables and fig.)

1936 **621 .116**
Mechanical Engineering, June, p. 372.
FOULK (C. W.). — **Suspended solids in the foaming and priming of boiler water.** (3 600 words.)

1936 **621 .43 & 621 .8**
Mechanical Engineering, June, p. 382.
Power transmission. — Starting acceleration of Diesel-driven cars. (1 500 words and fig.)

Modern Transport. (London.)

1936 **625 .1 (.42)**
Modern Transport, No. 897, May 23, p. 3.
Increased track capacity on the Southern Railway. No. 1. — « Flyover » to simplify Waterloo approach lines (700 words and fig.)

1936 **625 .232 (.41)**
Modern Transport, No. 897, May 23, p. 7.
Railway travel in Ireland. **Buffet cars** on Dublin-Belfast service. (600 words and fig.)

1936 **656 (.8)**
Modern Transport, No 897, May 23, p. 8.
Trade and Transport in Latin America. — **Railway and road schemes.** (2 000 words.)

1936 **656 .212 (.42)**
Modern Transport, No. 897, May 23, p. 9.
G. W. R. **freight facilities in Birmingham.** (2 100 words and fig.)

1936 **656 .212.6 (.42)**
Modern Transport, No. 897, May 23, p. 23.
L. M. S. freight facilities in Birmingham. — **Electric truck working** at Curzon Street. (1 600 words and fig.)

1936 **625 .1 (.42) & 656 .253 (.42)**
Modern Transport, No. 898, May 30, p. 3.
Automatic colour light signalling, Waterloo to Hampton Court Junction. (3 900 words and fig.)

1936 **656 .212 (.42)**
Modern Transport, No. 898, May 30, p. 5.
Railway passenger traffic facilities. Birmingham area operating facilities. (2 400 words.)

1936 **656**
Modern Transport, No. 898, May 30, p. 7.
PAYNE (H. W.). — The traders' part in transport. **Rail and road competition.** (3 400 words.)

1936 **621 .43 (.44)**
Modern Transport, No. 899, June 6, p. 5.
Diesel railcars in France. — P. L. M. and State railway services. (1 300 words and fig.)

1936 **621 .43 & 662**
Modern Transport, No. 899, June 6, p. 6.
Economising in motor vehicle running. — **Improved method of reclaiming waste oil.** (1 500 words and fig.)

1936 **621 .33 (.42)**
Modern Transport, No. 900, June 13, p. 3.
Electrifying a British main line. (7 400 words and fig.)

1936 **621 .33**
Modern Transport, No. 900, June 13, p. 10.
Forced draught for locomotives. — Adaptation of marine practice. (1 600 words.)

1936 **621 .132.3 (.4**
Modern Transport, No. 901, June 20, p. 3.
New express locomotives for L. N. E. R. — T« Green arrow », « Lord President », and additions « Silver Link » series. (1 400 words and fig.)

1936 **621 .132.5 (.5**
Modern Transport, No. 901, June 20, p. 4.
Metre-gauge locomotives for India. — « Y K » cla units for Assam-Bengal Railway. (1 500 words and fi

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1936 **621 .43 (.4**
Modern Transport, No. 901, June 20, p. 5.
British-built **railcars with pneumatic tyres.** (1 words and fig.)

1936 **621 .33 (.**
Modern Transport, No. 902, June 27.
WALKER (Sir Herbert). — **Electrifying the r** ways. Experience of the Southern Railway. (1 words and fig.)

1936 **621 .132.6 (.**
Modern Transport, No. 902, June 27, p. 5.
Tank locomotives for India for long-distance serv on South Indian Railway. (1 000 words and fig.)

1936 **625**
Modern Transport, No. 902, June 27, p. 7.
GLEDHILL (A. H.). — **The cost of transport.** (As taining fixed capital charges. (1 200 words and tabl

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Proceedings, American Society of Civil Engine (New York.)

1936 **62. (01 &**
Proceedings, Amer. Soc. of Civil Engineers, May, p.
WILLIAMS (H. A.). — **Dynamic distortions structures** subjected to sudden earth shock. (words and fig.)

1936 **62.**
Proceedings, Amer. Soc. of Civil Engineers, May, p.
FILON (L. N. G.) & SMITHS (H. G.). — **Ph elastic determination of shrinkage stresses.** (words and fig.)

Railway Age. (New York.)

1936 **656 .25 (.73) & 656 .222.1**
Railway Age, No. 18, May 2, p. 716.
ANDERSON (B. T.). — **Signaling for high-s trains.** (2 500 words and fig.)

1936 **625 .232**
Railway Age, No. 18, May 2, p. 719.
Union Pacific modernizes cars for « Challe (1 000 words and fig.)

1936 625 .13 (.73)
ilway Age, No. 18, May 2, p. 721.
Two bridge spans replaced in less than 18 days. 200 words and fig.)

1936 621 .43 (.73) & 625 .253 (.73)
ilway Age, No. 18, May 2, p. 723.
McCUNE (J. C.). — The brake problem of high-speed esel trains. (4 800 words.)

1936 656 .253 (.73) & 656 .256.3 (.73)
ilway Age, No. 19, May 9, p. 756.
New automatic signals on the Missouri Pacific. 000 words and fig.)

1936 625 .142.2 (.73) & 691 (.73)
ilway Age, No. 19, May 9, p. 759.
Vould eliminate the commercial treatment of rail-d timber. (2 200 words and 1 table.)

936 621 .43
ilway Age, No. 19, May 9, p. 763.
HURLEY (F. G.). — Diesel Engines in railway vice. (4 500 words.)

936 625 .13 (.73)
lway Age, No. 20, May 16, p. 792.
hift 90-ft. towers between trains in viaduct renewal. 00 words and fig.)

936 347 .763 (.73) & 385 .3 (.73)
lway Age, No. 20, May 16, p. 796.
AYLOR (H. G.). — Regulation ticket needs thin-g. (6 000 words.)

936 621 .132.8 (.65)
lway Age, No. 20, May 16, p. 803.
igh-speed articulated locomotives for Algeria. (1 000 ds, 1 table and fig.)

936 625 .24 (0 (.73) & 625 .26 (.73)
lway Age, No. 21, May 23, p. 826.
conomic aspects of the freight car situation. (2 800 ds and 4 tables.)

036 625 .162 (.73)
way Age, No. 21, May 23, p. 829.
ew York Railroad Club discusses the grade cross-problem. (4 600 words.)

036 656 .2 (.73)
way Age, No. 21, May 23, p. 839.
any 1935 railroad reports discuss motor transport ations. (2 200 words.)

036 656 .2 (.73)
way Age, No. 21, May 23, p. 843.
isting bus line refused permit. (1 400 words.)

36 621 .43 & 625 .232
way Age, No. 22, May 30, p. 864.
ion Pacific 11-unit streamliners ready for service. 0 words, tables and fig.)

1936 625 .142.2 (06 (.73)
Railway Age, No. 22, May 30, p. 879.
Tie Producers meet at Cincinnati. (3 300 words and fig.)

1936 656 .2 (.73)
Railway Age, No. 22, May 30, p. 882.
Wath's new in railroading ? (3 300 words.)

1936 624. (0 & 624 .2
Railway Age, No. 23, June 6, p. 906.
Impact on bridges - an achievement in research. (3 700 words and fig.)

1936 621 .13
Railway Age, No. 23, June 6, p. 910.
LIPETZ (A.). — Power plant on wheels. (5 700 words.)

1936 621 .43 (.73) & 659 (.73)
Railway Age, No. 23, June 6, p. 916.
Publicize success of new trains. (1 900 words and fig.)

1936 625 .234
Railway Age, No. 23, June 6, p. 919.
Air conditioning research now well underway. (1 700 words.)

1936 621 .139 (.73) & 625 .27 (.73)
Railway Age, No. 23, June 6, p. 921.
BROWN (W. F.). — Bin pricing in Wabash stores survives depression. (2 700 words and fig.)

Railway Engineering and Maintenance. (Chicago.)

1936 625 .171 (.73) & 625 .175 (.73)
Railway Engineering and Maintenance, May, p. 290.
Patrols replace track walkers on the New Haven. (3 300 words and fig.)

1936 625 .143.3 (.73) & 625 .171 (.73)
Railway Engineering and Maintenance, May, p. 293.
HOWE (C. H. R.). — Inspecting for bolt-hole breaks. (1 400 words.)

1936 624 .1 (.73) & 625 .13 (.73)
Railway Engineering and Maintenance, May, p. 295.
Underpins old masonry pier under severe difficulties. (3 200 words and fig.)

1936 621 .133.7 (.73) & 725 .33 (.73)
Railway Engineering and Maintenance, May, p. 299.
The lime-soda process. A review of methods and equipment. (2 500 words and fig.)

1936 625 .172 (.73)
Railway Engineering and Maintenance, May, p. 301.
HERALD (R.). — Surfacing track out-of-face. (850 words.)

1936 **625 .143.3 & 625 .143.4**
Railway Engineering and Maintenance, May, p. 302.
BRONSON (C. B.). — **Prolonging the life of rails.** (2 900 words and fig.)

1936 **625 .144.1 (.73)**
Railway Engineering and Maintenance, June, p. 352.
Mile-long rails installed in GEO test track. (2 400 words and fig.)

1936 **625 .156 (.73)**
Railway Engineering and Maintenance, June, p. 356.
Canadian Pacific builds **weatherproof scale-pit decks.** (1 000 words and fig.)

1936 **625 .151 & 625 .17**
Railway Engineering and Maintenance, June, p. 357.
SPYRES (O. L.). — **Maintaining turnouts.** (700 words.)

1936 **625 .13 (.73)**
Railway Engineering and Maintenance, June, p. 358.
Lowering a tunnel floor under traffic (2 600 words and fig.)

1936 **625 .123 (.73)**
Railway Engineering and Maintenance, June, p. 363.
A novel cure for water pockets. (1 500 words and fig.)

1936 **721 .2**
Railway Engineering and Maintenance, June, p. 366.
KETTERSON (A. R.). — **When an abutment tips.** (1 400 words.)

1936 **625 .142.2 (.73) & 625 .173 (.73)**
Railway Engineering and Maintenance, June, p. 368.
How many ties ? (1 000 words and fig.)

Railway Gazette. (London.)

1936 **625 .143.5**
Railway Gazette, No. 21, May 22, p. 990.
Behaviour of **screw fastenings in wooden sleepers.** (1 fig.)

1936 **625 .1 (.42)**
Railway Gazette, No. 21, May 22, p. 999.
Improving the approach to Waterloo Station. (1 200 words and fig.)

1936 **621 .132.8 (.43) & 625 .232 (.43)**
Railway Gazette, No. 21, May 22, p. 1003.
Streamlined double-deck trains, Lübeck-Büchen Railway. (900 words and fig.)

1936 **621 .132.8 (.942)**
Railway Gazette, No. 21, May 22, p. 1006.
New streamlined locomotive and centenary train, New Autralian Railways. (800 words and fig.)

1936 **656 .1 (.42) & 656 .26 (.42)**
Railway Gazette No. 21, May 22, p. 1010.
Ancillary businesses of the British Railways. IV. — **Road transport.** (1 100 words and 1 table.)

1936 **347 .763 (.42) & 656 .1 (.42)**
Railway Gazette, No. 22, May 29, p. 1032.
Second thoughts on the Road Traffic Acts. — Their effect on **road transport.** (1 250 words.)

1936 **625 .1 (.42) & 656 .25 (.42)**
Railway Gazette, No. 22, May 29, p. 1033.
Improving the approach to Waterloo. — II. — The new **signalling installation** of the Southern Railway between Waterloo and Hampton Court Junction incorporates several interesting features. (2 700 words and fig.)

1936 **625 .23**
Railway Gazette, No. 22, May 29, p. 1040.
Steam heating of railway carriages. (500 words and fig.)

1936 **624 .7 (.73**
Railway Gazette, No. 22, May 29, p. 1041.
New **rail and road bridge** at New Orleans. (500 words and fig.)

1936 **625 .231 (.4**
Railway Gazette, No. 22, May 29, p. 1042.
P. O.-Midi **ambulance or couchette coaches.** (4 words and fig.)

1936 **656 .26 (.4**
Railway Gazette, No. 22, May 29, p. 1051.
Ancillary businesses of the British Railways. — **Canals.** (1 000 words and tables.)

1936 **656 .283 (.4**
Railway Gazette, No. 22, May 29, p. 1052.
Ministry of Transport accident report : Barrow-Soar, L. M. S. R. : January 21, 1936. (1 500 words and fig.)

1936 **621 .392 (.65) & 621 .132.8 (.6**
Railway Gazette, No. 23, June 5, p. 1074.
Electrical apparatus for operating reversing g fitted to the 4-6-2 + 2-6-4 Beyer-Garratt locomotive for the Algerian Railways. (500 words and fig.)

1936 **621 .134.1 (.**
Railway Gazette, No. 23, June 5, p. 1081.
Cylinder castings for 4-6-0 type locomotives, L. M. Ry. (250 words and fig.)

1936 **621 .133.4 (.**
Railway Gazette, No. 23, June 5, p. 1082.
An American locomotive **chimney** design. (700 words and fig.)

1936 **656 (.**
Railway Gazette, No. 23, June 5, p. 1083.
Co-ordination (U. S. A.). (600 words and fig.)

1936 **656 (.43)**
ailway Gazette, No. 23, June 5, p. 1084.
Road and rail in Germany. (1 800 words.)

1936 **656 .2 (.73)**
ailway Gazette, No. 23, June 5, p. 1087.
Co-ordinated passenger travel in U. S. A. (900 words d fig.)

1936 **656 .26 (.42)**
ailway Gazette, No. 23, June 5, p. 1095.
Ancillary businesses of the British Railways. (750 rds and 1 table.)

1936 **621 .43 (.44)**
ailway Gazette, No. 23, June 5, p. 1096.
Charcoal-gas railcar experiments in France. (500 rds and fig.)

1936 **656 .257**
ilway Gazette, No. 24, June 12, p. 1115.
Electric interlocking. (1 400 words.)

1936 **665 .882**
ilway Gazette, No. 24, June 12, p. 1116.
Acetylene welding on railways. (Summary of papers sented to the XIIth International Congress of Acetene, London.) (1 200 words.)

1936 **656 .253 (.42)**
ilway Gazette, No. 24, June 12, p. 1117.
Bristol signalling alterations. **(Changing from manual to power signalling.)** (2 000 words and fig.)

1936 **621 .43 (.85)**
ilway Gazette, No. 24, June 12, p. 1120.
A new **six-wheeled rail passenger car** for Peru. (1 100 rds and fig.)

1936 **621 .9 (.42)**
ilway Gazette, No. 24, June 12, p. 1125.
Producing bolts from mild steel bars. — Installation Ward single-pulley headstock capstan lathes at we works, L. M. S. R. (250 words and fig.)

1936 **656 .222.1 (.42)**
lway Gazette, No. 24, June 12, p. 1130.
The Silver Jubilee, L. N. E. R. — Some details of **rent locomotive performance** on this high-speed ser-. (2 000 words, 1 table and fig.)

1936 **656 .222.1 (∞)**
lway Gazette, No. 25, June 19, p. 1168.
LLEN (C. J.). — **Railway speed development** in 5. (1 500 words, 5 tables and fig.)

1936 **621 .138.5 (.42) & 625 .26 (.42)**
lway Gazette, No. 25, June 19, p. 1171.
oncaster Works, L. N. E. R. (2 600 words.)

1936 **621 .43 (.42)**
lway Gazette, No. 25, June 19, p. 1173.
neumatic-tyred railcars for service in Britain. 00 words and fig.)

1936 **621 .132.3 (.42) & 621 .132.5 (.42)**
Railway Gazette, No. 25, June 19, p. 1177.
New three-cylinder 2-6-2 locomotives, L. N. E. R. (1 000 words and fig.)

1936 **385. (091 (.497.2)**
Railway Gazette, No. 26, June 26, p. 1205
BEAVER (S. H.). — **The Bulgarian State Railways.** (4 100 words and 1 map.)

1936 **621 .133.7 (.43)**
Railway Gazette, No. 26, June 26, p. 1207.
The Knorr feed-water heater. (700 words and fig.)

1936 **621 .132.5 (.54)**
Railway Gazette, No. 26, June 26, p. 1209.
New 2-6-0 standard locomotives, Assam-Bengal Railway. (550 words and fig.)

1936 **621 .132.3 (.71)**
Railway Gazette, No. 26, June 26, p. 1211.
New streamlined locomotives, Canadian National Railways. (600 words and fig.)

1936 **624 .63 (.42)**
Railway Gazette, No. 26, June 26, p. 1213.
An interesting **reinforced concrete railway overbridge.** (400 words and fig.)

1936 **621 .43 (.44)**
Diesel Ry. Traction, p. 1142, Supplt. to Ry. Gazette, June 12.
LAMBERT (M.). — The French **standard railcar.** (1 400 words and fig.)

1936 **621 .43 (.493) & 625 .26 (.493)**
Diesel Ry. Traction, p. 1144, Supplt. to Ry. Gazette, June 12.
VANDERPUTTE (Ed.). — The organisation of **Diesel railcar engine overhaul,** Belgian National Railways. (4 100 words and fig.)

1936 **621 .43 (.41)**
Diesel Ry. Traction, p. 1152, Supplt. to Ry. Gazette, June 12.
Articulated trains for Irish suburban service. (1 400 words and fig.)

1936 **621 .43 (.45) & 625 .23 (.45)**
Diesel Ry. Traction, p. 1154, Supplt. to Ry. Gazette, June 12.
Stainless steel railcars in Italy. (400 words and fig.)

1936 **625 .255**
Diesel Ry. Traction, p. 1155, Supplt. to Ry. Gazette, June 12.
SILLCOX (L. K.). — **Electro-magnetic track brakes.** (800 words.)

1936 **385 .113 (.73) & 621 .43 (.73)**
Diesel Ry. Traction, p. 1156, Supplt. to Ry. Gazette June 12.
More **Zephyr results.** (600 words.)

621 .338 (.436)

1936
Electric Ry. Traction, p. 1062, Supplt. to the Ry. Gazette, May 29.
New electric stock in Austria. (500 words and fig.)

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621 .335

1936
Electric Ry. Traction, p. 1063. Supplt. to the Ry. Gazette, May 29.
McKENZIE (D. B.). — **Electrical equipments on single-phase locomotives.** (1 100 words.)

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621 .337 (.73)

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Electric Ry. Traction, p. 1064, Supplt. to the Ry. Gazette, May 29.
A two-voltage crossing in America. (500 words and fig.)

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621 .33 (.47)

1936
Eleectric Ry. Traction, p. 1066, Supplt. to the Ry. Gazette, May 29.
ILINSKY (A. V.). — **The electrification of the Murmansk Railway.** (700 words and fig.)

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621 .336 (.492)

1936
Electric Ry. Traction, p. 1230, Supplt. to the Ry. Gazette, June 26.
BECKERING (H. W.). — **Pantograph construction and operation.** (3 500 words and fig.)

Railway Magazine. (London.)

654 (.42)

1936
Railway Magazine, June, p. 391.
KNOWLMAN (C.). — **Railway telegraphs.** (3 200 words and fig.)

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1936
Railway Magazine, June, p. 398.
PEIRSON (J. G.). — **Railways of the Congo.** (2 300 words and fig.)

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656 .254 (.42)

1936
Railway Magazine, June, p. 402.
A novel L. N. E. R. signalling development. (1 300 words.)

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656 .222.1 (.42)

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Railway Magazine, June, p. 403.
ALLEN (C. J.). — **British locomotive practice and performance** (3 900 words, tables and fig.)

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385. (091 (.42)

1936
Railway Magazine, June, p. 413.
NOCK (O. S.). — **The N. C. C. section of the L. M. S. R.** - Part II. (4.600 words and fig.)

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385. (091 (.71)

1936
Railway Magazine, June, p. 427.
SOOLE (G. H.). — « **Field Hill** » **on the C. P. R.** (3 000 words and fig.)

621 .132.8 (.65)

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A new streamlined « Garratt ». Algerian Railways (700 words and fig.)

Railway Mechanical Engineer. (Philadelphia.)

62. (01 & 669

1936
Railway Mechanical Engineer, May, p. 179.
PRIEST (H. M.). — **Designing for high-tensile steel** (3 600 words, 6 tables and fig.)

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313 : 625 .234 (.7

1936
Railway Mechanical Engineer, May, p. 184.
Six-year summary of air conditioned cars. (2 table

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1936
Railway Mechanical Engineer, May, p. 185.
The Green Diamond. — **Five-car articulated tra powered with 1 200-hp. Diesel engine,** weighs 476 800 seats 144 persons and costs $ 425 000. (3 500 wo and fig.)

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621 .13 & 656 .

1936
Railway Mechanical Engineer, May, p. 190.
WILLIAMS (F. H.). — **Failures of locomotive pa** (1 400 words and fig.) (To be continued.)

621

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Railway Mechanical Engineer, May, p. 193.
CANDEE (A. H.). — **Railroad Diesel engineer** (4 500 words and fig.)

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621 .43 (

1936
Railway Mechanical Engineer, May, p. 197.
Illinois Central 1 800 h.p. Diesel locomotive. (words and fig.)

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625 .211.4 (.73) & 625 .26

1936
Railway Mechanical Engineer, May, p. 213.
GRANT (L. E.). — **Relining rod bearings by c** fugal process. (2 200 words and fig.)

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621 .392 (.73) & 621 .113 (06

1936
Railway Mechanical Engineer, May, p. 215.
Fusion welding on boiler and tanks. (1 000 and fig.)

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621 .138.5

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Railway Mechanical Engineer, June, p. 225.
Modern methods and facilities effect econom Reading locomotive shop. (3 300 words and fig.

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CANDEE (A. H.). — **Railroad Diesel engin** (5 200 words and fig.)

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PRIEST (H. M.). — **Designing for high-tensile** (3 400 words and fig.)

1936 **62. (01, 621 .43 & 669 .1**
ilway Mechanical Engineer, June, p. 249.
VILLIAMS (F. H.). — **Failures of locomotive parts.**
400 words and fig.)

1936 **625 .26 (.73)**
lway Mechanical Engineer, June, p. 256.
'ort Huron, Mich., **car shops.** (2 700 words and fig.)

1936 **665 .882**
lway Mechanical Engineer, June p. 269.
nspecting and repairing oxy-acetylene equipment.
00 words and fig.)

Railway Signaling. (Chicago.)

936 **656 .253 (.73) & 656 .254 (.73)**
lway Signaling, May, p. 247.
emote control involving Santa Fe and Rock Island.
00 words and fig.)

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936 **656 .25 (.73) & 656 .284 (.73)**
way Signaling, May, p. 251.
ailroads clean up after flood waters. (Methods pur-
l in replacing and rehabiliting the signaling and
rlocking facilities after the floods receded.) (11 000
ds and fig.)

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936 **656 .258 (.73)**
way Signaling, May, p. 261.
ew electric interlocking and signaling at the Missis-
River Bridge at New Orleans. (3 000 words and fig.)

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936 **656 .254 (.73)**
way Signaling, May, p. 265.
JDD (A. H.). — **Cab signaling.** (2 300 words
fig.)

The Locomotive. (London.)

36 **621 .132.5 (.68)**
Locomotive, May 15, p. 133.
3-2 heavy goods engines, South African Railways.
0 words and fig.)

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36 **621 .43 (.42 + .54)**
Locomotive, May 15, p. 137.
esel electric shunting locomotives. — London Mid-
and Scottish Railway. — Bombay, Baroda and
ral India Railway. (2 200 words and fig.)

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36 **621 .132.3 (.73)**
Locomotive, May 15, p. 142.
-4 passenger locomotives, Chesapeake and Ohio
(800 words and fig.)

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36 **621 .132.8 (.9)**
Locomotive, May 15, p. 144.
rrow-gauge Beyer-Garratt locomotive, for Victoria.
words and fig.)

1936 **621 .9 (.42)**
The Locomotive. May 15, p. 150.
Axlebox boring, facing and radiusing machine. (1 500 words and fig.)

1936 **621 .43 & 623**
The Locomotive, May 15, p. 152.
Armoured railcars. (2 100 words.)

1936 **621 .138.5**
The Locomotive, May 15, p. 154.
CARLISLE (W. E.). — **Jigs, fixtures, and notes on production.** (2 700 words and fig.) (To be continued.)

1936 **621 .13 (06 (.42)**
The Locomotive, May 15, p. 159.
Some suggestions on steam locomotive design. (2 700 words.)

1936 **621 .132.6 (.54)**
The Locomotive, June 15, p. 168.
2-6-4 type P. T. class broad gauge tank engines, South Indian Railway. (850 words and fig.)

1936 **621 .132.8 (.44)**
The Locomotive, June 15, p. 173.
A French **steam railcar.** (300 words and fig.)

1936 **621 .132.5 (.68)**
The Locomotive, June 15, p. 174.
2-10-2 locomotive South African Railways (400 words and fig.)

1936 **621 .43 (.82)**
The Locomotive, June 15, p. 176.
Diesel-electric railcars provincial Railway of Buenos-Aires. (600 words and fig.)

1936 **621 .132.5 (.72)**
The Locomotive, June 15, p. 181.
Narrow gauge articulated locomotive, National Railways of Mexico. (600 words and fig.)

1936 **621 .135.4 & 625 .215**
The Locomotive, June 15, p. 183.
A recent « heavy » bogie design. (1 900 words and fig.)

The Oil Engine. (London.)

1936 **621 .43 (.42)**
The Oil Engine, June, p. 40.
A **Diesel railcoach** in military service. — Drewry coach, 68 b. h. p. Gardner-engined, for instructional purposes. (800 words and fig.)

1936 **621 .43 (.73)**
The Oil Engine, June, p. 52.
MANN (Ch. F. A.). — The latest American **133-ton locomotive.** (700 words and fig.)

621 .43 (.73)

1936

The Oil Engine. June, p. 53.

Streamline Diesel-train development in America. — A new order by the Santa Fé Railroad; the latest train of the Union Pacific Company. (800 words.)

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621 .43 (.42)

1936

The Oil Engine, June, p. 57.

Problems of **combustion chamber design.** — The development of the Fowler-Sanders swirl system discussed by the D. E. U. A. (1 300 words.)

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1936

The Oil Engine, June, p. 58.

GURLEY (F. C.). — **High-speed oil-engined trains in service.** (A comparison with steam trains by a railway official, based on several years' operation.) (1 500 words.)

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621 .43 (.489)

1936

The Oil Engine. June. p. 60.

A standard 450 b. h. p. Diesel locomotive. — The latest Frichs type for local services. (900 words and fig.)

In Spanish.

Anales de la Asociación de Antiguos Alumnos del I. C. A. I. (Madrid.)

621 .335

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Anales de la Asociación de Antiguos Alumnos del I. C. A. I., mayo, p. 251.

LAZARO (P. V.). — **El control electrico en las locomotoras y automotores de corriente continua.** (3 400 palabras & fig.)

Boletín de la Asociación General de transportes por vía férrea. (Madrid.)

621 .43

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Boletín de la Asociación General de transportes por vía férrea, suplemento, abril, p. 49.

Sobrealimentación de los motores de explosión y especialmente de los Diesel de cuatro tiempos. (2 100 palabras & fig.)

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621 .43

1936

Boletín de la Asociación General de transportes por vía férrea, suplemento, abril, p. 53.

Nuevo motor Diesel-Mercedès Benz de 450/550 C. V. para automotores. (1 900 palabras & fig.)

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621 .43

1936

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La lubricación económica de los motores Diesel de alta y media velocidad para tracción. (2 900 palabras & fig.)

Caminos de hierro. (Madrid.)

65

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Caminos de hierro, abril, p. 93.

Los servicios combinados entre el ferrocarril y l carretera. (1 400 palabras & fig.) (Continuará.)

Ferrocarriles y Tranvías. (Madrid.)

385. (09.3 (.46

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Ferrocarriles y Tranvías, mayo, p. 130.

ARRILLAGA (M. M.). — **La red ferroviaria esp** ñola. Su origen y constitución. (8 000 palabras & fi

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621 .132.3 (.4

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Ferrocarriles y Tranvías, mayo, p. 140.

HEISE (G.). — El primer **train aerodinámico** vapor de los ferrocarriles Alemanes. (4 200 palab & fig.)

Ferroviarios. (Madrid)

385 .517 (.4

1936

Ferroviarios, mayo, p. 12.

LOZANO (L.). — El Servicio de **Asistencia So** creado por la Compañía de Madrid-Zaragoza-Alica (1 200 palabras & fig.)

Hormigón y Acero. (Madrid).

624 .51 (

1936

Hormigón y Acero, abril, p. 157.

El **puente** de Triborough, en Nueva York. (600 bras & fig.)

6

1936

Hormigón y Acero, mayo, p. 167.

CHWALLA (E.). — **La resistencia de barra** sección variable sometidas a flexión compuesta. palabras & fig.) (Continuará.)

Rieles argentinos. (Buenos Aires.)

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Rieles argentinos, abril, p. 79.

La situación de los ferrocarriles extranjeros nuestro país. (2 400 palabras & fig.)

In Italian.

Annali dei lavori pubblici. (Roma.)

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Annali dei lavori pubblici, maggio, p. 320.

TARANTINI (A.). — **Un caratteristico ponte in cemento armato.** (5 400 parole & fig.)

La tecnica professionale. (Firenze.)

1936 **656 .221**

a tecnica professionale, guigno, p. 126.

Le esperienze sulla **resistenza aerodinamica dei vei-li ferroviari.** (4 500 parole & fig.)

Rivista tecnica delle ferrovie italiane. (Roma.)

1936 **621 .138.5 (.45)**

Rivista tecnica delle ferrovie italiane, 15 maggio, p. 247.

GIORGI (G. de). — **La riparazione in serie dei tubi llitori.** Il nuovo impianto nelle officine F. S. in Fi-nze. (3 300 parole & fig.)

1936 **725 .31 (.45)**

Rivista tecnica delle ferrovie italiane, 15 maggio, p. 257.

CHECCUCCI (G.). — **Costruzione della nuova sta-ne di Firenze S. Maria Novella.** Successione delle si esecutive. (2 700 parole & fig.)

In Dutch.

De Ingenieur. (Den Haag.)

1936 **621 .43**

Ingenieur, N° 22, 29 Mei, p. W. 90.

BOERLAGE (G. D.), BROEZE (J. J.), LE MESU-ER (L. J.). & STANSFIELD (R.). — Correlatie-beven over **ontstekingsqualiteiten van Dieselbrand-offen.** (900 woorden & fig.)

1936 **621 .43 (.493)**

Ingenieur, N° 22, 29 Mei, p. W. 91.

HUPKES (W.). — **Diesel-electrische tractie** op de derlandsche Spoorwegen. (500 woorden.)

1936 **621 .43**

Ingenieur, N° 22, 29 Mei, p. W. 92.

BARTON (C. H.). — Specificaties van **Dieselbrand-ffen.** (700 woorden.)

1936 **621 .43**

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HAGEMANN (A.) & HAMMERICH (Th.). — Mo-ne **beproevingsmethoden van brandstoffen** voor snel-pende Dieselmotoren. (500 woorden.)

1936 **721 .9**

Ingenieur, N° 23, 5 Juni, p. Bt. 31.

ZWIKKER (C.). — **Acoustische problemen bij de onbouw.** (3 600 woorden & fig.)

1936 **624 .8 (.492)**

Ingenieur, N° 24, 12 Juni, p. B. 93.

BIEMOND (C.), VAN WALRAVEN (A.) & VAN NDICK (I.). — De **Mariniersbrug.** (5 000 woorden fig.)

Spoor- en Tramwegen. (Utrecht.)

1936 **656 .1 (.92)**

Spoor- en Tramwegen, N° 11, 26 Mei, p. 247.

BEUKELMAN (H. R.). — De nadere aanvulling en wijziging van de **wegverkeersordonnantie** in Nederlandsch-Indië. (3 800 woorden.)

1936 **656 (.492)**

Spoor- en Tramwegen, N° 11, 26 Mei, p. 253.

JAGT (A. G.). — **De spoorwegen en het verkeers-probleem.** (3 700 woorden.)

1936 **621 .131.1**

Spoor- en Tramwegen, N° 12, 9 Juni, p. 271.

LABRIJN (P.). — **Het vermogen van stoomlocomo-tieven.** (2 200 woorden, 3 tabellen & fig.)

1936 **625 .61 (0 (.492)**

Spoor- en Tramwegen, N° 12, 9 Juni, p. 281.

Samenwerking tusschen de Nederlandsche Spoorwe-gen en de Geldersche tramwegen. (1 000 woorden & 1 kaart.)

In Polish.

(= 91.885)

Inżynier Kolejowy. (Warszawa).

1936 **621 .139 = 91 .885, 625 .18 = 91 .885 & 625 .27 = 91 .885**

Inzynier Kolejowy, May, p. 162.

MICHALSKI (W.). — **Organisation of the Stores Department** in Poland and on other Railways. (5 400 words.)

1936 **621 .132.3 (.51) = 91 .885**

Inzynier Kolejowy, Mai, p. 167.

DOMANIEWSKI (S.). — First Polish-built **locomo-tive** for China. (3 600 words and fig.)

1936 **621 .131.3 (.498) = 91 .885**

Inzynier Kolejowy, May, p. 171.

CZECZOTT (A.). — **New locomotive testing service** of the Rumanian Railways. (1 900 words and fig.)

1936 **621 .43 = 91 .885**

Inzynier Kolejowy, June, p. 193.

OGUREK (O.). — **Diesel-hydraulic railcar.** (4 100 words and fig.)

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Inzynier Kolejowy, June, p. 201.

BESSAGA (M.). — **Curve adjustment** by the versine-measuring method. (3 000 words and fig.)

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1936 **624. (02**
JBRY (Ch.).
nstructions relatives au calcul et à la surveillance ouvrages métalliques et en béton armé.
Paris, Ecole spéciale des Travaux publics, 1 volume, 3 pages et figures. (Prix : 30 fr. français.)

1936 **691. (02**
RIS (A.).
Cours de béton armé.
Paris, Dunod, 92, rue Bonaparte, 1 volume, 474 pages, tableaux et 66 figures. (Prix : 140 fr. français.)

1936 **625 .258**
BOURDIN.
Étude du freinage des wagons dans les gares de ıge.
Paris-VIIIe, Comité National de l'Organisation Fran-se, 11bis, rue d'Aguesseau, 1 fascicule, 16 pages et ires.

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1935 **624. (06**
Abhandlungen der Internationalen Vereinigung für ickenbau und Hochbau.
Zürich, Gebr. Leemann & Cº. 1 Band, 438 Seiten mit lern. (Preis : 30 Schw. Franken.)

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FLŒGEL (J.).
Strassenverkehrsrecht. (Reichsstrassenverkehrsordnung und Gesetz über den Verkehr mit Kraftfahrzeugen nebst ergänzenden Vorschriften.)
München und Berlin. 1 Band, 384 Seiten und 21 Tafeln. (Preis : 7.50 R. M.)

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Berlin, VDI-Verlag. 1 Band, 57 Seiten, 80 Tafeln und 140 Abbildungen. (Preis : 48 R. M.)

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Erläuterungen zu den Vorschriften für geschweisste Stahlbauten mit Beispielen für die Berechnung und bauliche Durchbildung.
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Handbuch für Eisenbetonbau. 4. Auflage, 12. Band, 3. Lieferung : Strassen-, Eisenbahn-, Berg- und Tunnelbau.
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Wien, Julius Springer. 1 Band. (Preis : 1.45 R. M.)

(1) The numbers placed over the title of each book are those of the decimal classification proposed by the Railway Congress jointly with the Office Bibliographique International, of Brussels. (See « Bibliographical Decimal Classification as applied to ilway Science », by L. WEISSENBRUCH, in the number for November 1897, of the *Bulletin of the International Railway Congress*, 1509).

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A review of railway operation in 1935.
Washington, D. C. Bureau of Railway Economics, Association of American Railroads. Special series nº 64.

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CANADIAN NATIONAL RAILWAY SYSTEM.
Some of the causes of Government ownership abroad and how Government ownership came about in Canada.
Chicago, Ill. Two pamphlets published by the Transportation Association of America. Transportation Building, Chicago, Ill.

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Fatigue test of welded connections.
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VINSON (P.). — **La sous-station automatique de traction d'Argenteuil.** (1 800 mots & fig.)

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PAHIN (A. H.). — **Automotrices Diesel-électriques** pour grands réseaux et pour chemins de fer secondaires. (2 300 mots & fig.)

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HUSBAND (J.). — Les **ponts** de la Baie de San-Francisco. (4 000 mots & fig.)

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LEPAGE. — **Terminus automatiques** sur la ligne d'Auteuil. (1 000 mots & fig.)

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L'**automotrice Decauville 600 CV.** du Paris-Lyon-Méditerranée. (1 200 mots & fig.)

1936 **621 .43 (.73)**

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Verbesserungen an den Pacificlokomotiven der Paris-Lyon-Mittelmeer Bahn. (4 800 Wörter & Abb.)

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1 C Heissdampf-Schnellzuglokomotive für Nord-Irland. (1 900 Wörter & Abb.)

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Bo-Bo-Einphasen-Gepäcktriebwagen Reihe ET 30 der Österr. Bundes-Bahnen. (1 000 Wörter.)

Die Reichsbahn. (Berlin.)

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SCHNELL. — Die neuen **Personenwagenvorschriften.** (1 200 Wörter.)

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Die Reichsbahn, Heft 27, 1. Juli, S. 544.

MARTENS (H. A.) — Betriebsverbundenheit, die Grundlage der **Unfallverhütung** im Betriebsmaschinen- und Werkstättendienst der Deutschen Reichsbahn. (2 300 Wörter & Abb.)

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Die **Gesellschaft « Reichsautobahnen »**. Ende Mai 1936. (600 Wörter.)

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GRASSL (R.) & TASCHINGER (O.). — **Aussichtstriebwagen** mit Antrieb durch Dieselmotoren. (1 400 Wörter & Abb.)

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KRISTENSEN (J.). — Die **Elektrisierung** des Nahverkehrs von Kopenhagen. (4 700 Wörter & Abb.)

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HARTMANN. — Neuerungen an den **Weichen** der Deutschen Reichsbahn. (9 600 Wörter & Abb.)

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FEYL (E.). — Die **neuen Weichen Form B** der Österreichischen Bundesbahnen. (5 600 Wörter & Abb.)

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SALLER. — Neue Vorschriften der Sowjetbahnen für **Spurweite und Gleisüberhöhung.** (600 Wörter.)

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GARBERS. — Die **Fahrzeuglager** der Deutschen Reichsbahn. (14 000 Wörter & Abb.)

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MAUCK (P.). — Erfahrungen mit einem **Dampftriebzug.** (2 500 Wörter & Abb.)

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RUTTMANN (W.). — **Festigkeitseigenschaften der Stähle** bei hohen Temperaturen. (1 400 Wörter & Abb.)

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KRAUSKOPF (L.). — Neuere Entwicklung auf dem Gebiete der **Zugbeeinflussung.** (3 200 Wörter & Abb.)

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HERWIG & BUDDENBERG. — Die **Reichsbahnweichen.** (1 000 Wörter & Abb.)

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1936 **385 .63**
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LILLIENDAHL (A.). — Das **Problem von Schiene und Strasse** in Schweden. (3 400 Wörter.)

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he Golden Gate Bridge. (5 300 words.) (To be con- ued.)

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TAPSELL (H. J.), BECKER (M. L.) & CONWAY (C. G.). — **Creep and growth of cast irons.** — The behaviour of five cast irons in relation to creep and growth at elevated temperatures. (3 000 words, tables & fig.)

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1936 **62. (01 & 621 .89**

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The Sperry-Cammen Adher-O-Scope for testing **lubricating oils.** (1 300 words & fig.)

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The Noel **high-speed arc welder.** (1 300 words & fig.)

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STRAUSS (F.). — **Protecting railways against a raids.** — Measures adopted on the Continent. (1 6 words.)

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New class of 4-4-0 locomotive for Q. W. Ry. (7 words & fig.)

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1936 **656 .212.7 (.4**
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« **Cost finding** » **plan proposed.** (5 300 words).

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Train service rules surveyed. (7 000 words & tables.)

1936 **656 .24 (06 (.73)**

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Freight Claim Division meeting. (2 000 words & fig.)

1936 **625 .1 (.73) & 725 .3 (.73)**

ilway Age, No. 25, June 20, p. 983.

Lehigh Valley combs property for unnecessary facies. (1 600 words & fig.)

1936 **385 .3 (.73), 621 .138 (.73) & 625 .26 (.73)**

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Co-ordinator reports on **consolidation and modernization of shops.** (3 400 words & tables.)

1936 **656 .225 (.73)**

ilway Age, No. 25, June 20, p. 997.

Containers on Nation-wide scale. (4 200 words & fig.)

1936 **625 .215 (.81)**

ilway Age, No. 25, June 20, p. 1002.

Alloy truck frames and bolsters for Brazil. (400 rds, 1 table & fig.)

1936 **313 : 625 .143.3 (.71)**

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BARNES (W. C.). — **Rail failure statistics for 1934.** 00 words & fig.)

1936 **385. (061.4 (.73) & 621. (06 (.73)**

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Mechanical Division (A. A. R.) holds meeting at Chigo. — Abstracts of reports and discussion on : akes and brake equipment; Safety appliances; Specialation for materials; Electric rolling stock; Car nstruction; Air conditioning and equipment; Lighting; nk cars; Lubrication of cars and locomotives; Loag rules; Wheels; Locomotive construction; Arbitran; Cost of billing for foreign freight-car repairs; ices for labor and materials; Couplers an draft gears. 5 000 words & fig.)

1936 **656 .261 (.73)**

Railway Age, No. 26, June 27, p. 1053.

Inter-city trucking proves efficient. — Missouri Pacific establishes a number of cross-country routes to provide more flexible service for branch line towns. (1 600 words & fig.)

1936 **656 .1 (.73)**

Railway Age, No. 26, June 27, p. 1058.

Many 1935 railroad reports discuss **motor transport operations.** (3 500 words.)

1936 **621 .43 (.73) & 625 .232 (.73)**

Railway Age, No. 1, July 4, p. 4.

The new **streamliner « City of Denver ».** (3 200 words & fig.)

1936 **656 .262 (.73)**

Railway Age, No. 1, July 4, p. 22.

Co-ordinator's report on **dining car supplies aired.** (1 200 words & 2 tables.)

1936 **625 .143.2 (.73)**

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MOORE (H. F.). — Further progress in **study of rails.** (3 300 words & fig.)

1936 **385 .3 (.73) & 656 .261 (.73)**

Railway Age, No. 1, July 4, p. 29.

C. and D. hearings at New York. (3 300 words.)

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1936 **621 .132.3 (.42)**

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2-8-2 type three-cylinder engines, L. N. E. R. (600 words & fig.)

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Colour-light signalling at Leeds new station, L. N. E. R. (800 words & fig.)

1936 **656 .1 (.68)**

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ARTHURTON (A. W.). — **Road motor services** of the South African Railways. (800 words & fig.)

1936 **656 .1 (.44)**

Railway Gazette, No. 1, July 3, p. 20.

The cost to the French Railways of their road subsidiaries. (300 words & 2 tables.)

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Railway Gazette, No. 2, July 10, p. 48.

Locomotive performance on the Nord. The work of the latest 2-8-2 tank and 2-10-0 freight types. (1 800 words.)

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Corrosion of painted structures. (800 words.)

1936 **625 .143.5**
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Reinforcing rail-to-sleeper fastenings. (450 words & fig.)

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Michelin developments. — The French State Railways introduce two high-capacity types. (800 words & fig.)

1936 **621 .132.5 (.42)**
Railway Gazette, No. 2, July 10, p. 55.
New express freight locomotives, Southern Railway. (300 words & fig.)

1936 **625 .232 (.42)**
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Pullman buffet car for Newhaven boat trains. (300 words & fig.)

1936 **656 .28 (01 (.42)**
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Colonel Mount's **annual report.** (2 400 words.)

1936 **606 .233 (.42)**
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Midland and Great Northern **Railway management changes.** (1 000 words & fig.)

1936 **621 .392 (.439) & 625 .43 (.439)**
Railway Gazette, No. 3, July 17, p. 105.
Arc-welded rail joints. (2 200 words & fig.)

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Railway Gazette, No. 3, July 17, p. 109.
New Portsmouth **goods depot,** Southern Railways. (1 300 words & fig.)

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Railway Gazette, No. 3, July 17, p. 111.
Modified Japanese **streamlined locomotive.** (400 words & fig.)

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Ballast edge plough, L. N. E. R. (300 words & fig.)

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New oxygen cutting machine. (350 words & fig.)

1936 **385. (091 (.56)**
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Railway development in Asiatic Turkey. (900 words & fig.)

1936 **625 .234 (.73)**
Railway Gazette, No. 4, July 24, p. 133.
Steam heating and air conditioning. (900 words.)

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FORKHAMMER (N.). — **Monogram for D. C. track circuits.** (3 500 words & fig.)

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The Fuka to Mersa Matrouh extension, Egyptia State Railways. (1 100 words & fig.)

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The mechanics of railway track. (500 words & fig.)

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1936 **656 .281 (.42**
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Main line Diesel-electric locomotive in the U. S. A (800 words & fig.)

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Further Diesel advance on the M. Z. A. (1 300 wor & fig.)

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A new G. W. R. Diesel-electric shunter. (300 wor & fig.)

1936 **621 .43 (.7**
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New **Cross-Continent Diesel trains** in America. (1 60 words & fig.)

1936 **621 .43 (.4**
Diesel Ry. Traction, p. 91, Supplt. to the Ry. Gazett July 10.
Gleniffer **oil engine** for shunting locomotive. (4 words & fig.)

936 **621 .33 (.44)**

ctric Ry. Traction, p. 166, Supplt. to the Ry. Gazette, July 24.

he electrified suburban lines of the French State lways. (2 400 words & fig.)

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936 **621 .338 (.42)**

ctric Ry. Traction, p. 172, Supplt to the Ry. Gazette, July 24.

lew train for the London Underground. (400 words ig.)

Railway Magazine. (London.)

936 **625 .232 & 656 .25**

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EGG (W. W.). — **Intercommunication in passenger ns.** — Familiar features — XIII. (3 800 words ig.)

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mproving the approach to Waterloo Station, uthern Ry. (850 words & fig.)

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936 **621 .132.1 (.94)**

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.ustralian locomotive development. (3 000 words &)

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LLIS (C. H.) & LEE (Ch. E.). — **The Festiniog lway.** Part II. (4 000 words & fig.)

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936 **656 .258 (.73)**

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'LEISHER (H. T.). — New **electro-pneumatic plant** Pennsylvania at Newark. (6 600 words & fig.)

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936 **625 .162 (.73) & 656 .259 (.73)**

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lashing lights at 20 crossings in Kalamazoo. (2 500 ds & fig.)

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lway Signaling, June, p. 309.

OBERTS (L. C.). — « **Balance** » **in dispatching cir-ts.** (2 300 words & fig.)

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936 **621 .85 (.73) & 656 .25 (.73)**

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VHITE (W. W.). — Southern Railway operates **nal shop** at Lexington, Ky. (2 200 words & fig.)

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lway Signaling, June, p. 318.

What is the capacity of a single-track line ? (800 ds.)

The Oil Engine. (London.)

1936 **385 .113 (.489) & 621 .43 (.489)**

The Oil Engine, July, p. 70.

Operating results with the first complete Diesel express train service (Denmark). (2 200 words & fig.)

1936 **621 .43 (.73)**

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MANN (Ch. F. A.). — **The largest Diesel trains.** Four double-engined 11-and 12-car trains with 2 100 b.h.p. and 2 400 b.h.p. machinery for transcontinental express services on the Union Pacific Railroad, U. S. A. (2 400 words & fig.)

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1936 **385 .071.3 (.71) & 385 .587 (.71)**

Transit Journal, June, p. 183.

Making transportation men. (2 000 words & fig.)

In Spanish.

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Bol. de la Asoc. Gener. de transp. por vía férrea, Suplemento, mayo, p. 61.

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Sobrealimentación de los motores de explosión y especialmente de los Diesel de cuatro tiempos. (5 000 palabras & fig.)

Ferrocarriles y Tranvías. (Madrid.)

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Ferrocarriles y Tranvías, Junio, p. 162.

SANTIAGO (E.). — **Resultados obtenidos con los automotores** en la Compañía de M. Z. A. (4 400 palabras & fig.)

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ONTIVEROS (F. J.). — **Estudio económico de las explotaciones ferroviarias.** (8 200 palabras & fig.)

Ingeniería y Construcción. (Madrid.)

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SERRAT Y BONASTRE (J.). — **Las nuevas locomotoras,** serie 4.251-55, de la Compañía de los Ferrocarriles Andaluces. (1 900 palabras & fig.)

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Rieles argentinos. (Buenos Aires.)

1936 **385 (.3)**

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La **situación de los ferrocarriles** extranjeros y de nuestro país. (3 800 palabras).

1936 **625 .13 (.43)**

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El **túnel** bajo el Elba. (2 900 palabras & fig.)

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VILLALBA GRANDA (C.). — El **puente** sobre el río Guadalhorce, en Pizarra, Málaga. (2 600 palabras & fig.)

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ANGULO (A.). — Nuevas posibilidades del **hormigón armado.** (1 600 palabras.)

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1936 **621 .33**

La tecnica professionale, luglio, p. 151.

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1936 **621 .133.7**

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Sul **trattamento dell' acqua** nell' interno delle caldaie delle locomotive. (3 900 parole & fig.)

L'Ingegnere. (Roma.)

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Il **nuovo ponte sul Ticino** a Pavia per la strada statale dei Giovi. (1 200 parole & fig.)

In Dutch.

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1936 **65**

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NIEUWENHUIS (J. G. J. C.). — Het **secundair vervoer** in crisistijd. (12 000 woorden, 15 tabellen & fig

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Spoor- en Tramwegen. (Utrecht.)

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ASSELBERGHS (H.). — Artistieke gedenkpenning in het **Nederlandsch Spoorwegmuseum.** (3 800 woorden & fig.)

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NIEUWENHUIS (J. G. J. C.). — Het **tramspoor** den openbaren weg. (1 400 woorden & fig.)

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De **reorganisatie** der Nederlandsche Spoorwege (3 200 woorden.)

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VAN DER VEEN (K. H. C. W.). — De **bovenbouw van de overbrugging** der Oosterdoksluizen in Amsterdam-Oost. (3 100 woorden & fig.)

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GROOT (A. M.). — Preciseering van het princi « **What the traffic can bear** ». (3 000 woorden & fig

In Rumanian.

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MOCEAROV (N.). — The « **Rona** » **locomotive meter.** 800 words & fig.)

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M. Weissenbruch Co., Ltd., Printer of the King, 49, rue du Poinçon, Bruxelles.

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In French.

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Paris, J. B. Baillière et Fils. 1 volume, 376 pages et 8 figures. (Prix : 22 fr. français.)

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Praha, Direction des Chemins de fer de l'Etat. 1 volume, 123 pages et 1 carte.

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Praha, Direction des Chemins de fer de l'Etat. 1 volume, 240 pages.

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ORN (E.).

Die Schnell- und Leichttriebwagen der Deutschen eichsbahn im Bild.

Berlin, Verkehrswissenschaftliche Lehrmittelgesellhaft m. b. H. bei der Deutschen Reichsbahn und armstadt, Technische Hochschule. 1 Band, 47 Seiten nd 30 Abbildungen. (Preis : 1.80 R.M.)

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Die Korrosion metallischer Werkstoffe. Band I : **Die orrosion des Eisens und seiner Legierungen.**

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Aluminiumlegierungen.

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Verkehrsstatistik.

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Wien, Julius Springer, Schottengasse, 4. 1 Band, 22 Seiten. (Preis : 1.45 R.M.)

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Düsseldorf, Verlag Stahleisen und Berlin, Julius Springer. 1 Band, 780 Seiten und Abbildungen. (Preis : 12 R.M.)

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Plain concrete.

New York & London. Published by McGraw-Hill Book Co. 2nd edition (6 × 9 inches), 364 pages, photographs, drawings and tables. (Price : $ 4.00.)

(1) The numbers placed over the title of each book are those of the decimal classification proposed by the Railway Congress conjointly with the Office Bibliographique International, of Brussels. (See « Bibliographical Decimal Classification as applied to Railway Science », by L. WEISSENBRUCH, in the number for November 1897, of the *Bulletin of the International Railway Congress*, p. 1509).

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936 **62. (01**

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936 **621 .43 (.44)**

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HAUMEL (Y.). — Les **autorails Diesel électriques** liet-Alsthom de 250 C. V. (3 400 mots & fig.)

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936 **621 .43**

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NEGRE (A.). — **Evolution du moteur Diesel** et réa- tions récentes dans les différents modes d'applica- n. (3 500 mots & fig.)

Le Container. (Paris.)

936 **656 .225 & 656 .261**

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le BOYSSON (L.). — Le développement du trafic containers. (2 000 mots.)

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PERIDIER (J.). — Conversion des équipements de action en vue de la **récupération.** (4 500 mots & fig.)

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VENTE. — Chronique de la **coordination** à l'étranger. 000 mots.)

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1936 **62. (01**

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ROUZET (L.). — Contribution à la théorie de la **sistance des matériaux** appliquée au calcul des res- rts. (3 400 mots & fig.)

1936 **691 & 721 .9**

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1936 **388 (.42) & 656 (.42)**

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1936 **625 .23 (.44)**

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PONCET & FORESTIER. — **Voitures de banlieue métalliques allégées.** (6 000 mots & fig.)

1936 **625 .215 (.44) & 625 .26 (.44)**

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LE HORGNE. — La **réparation des bogies de voitures** aux chemins de fer de l'État. (2 200 mots & fig.)

1936 **625 .13 (.44)**

Revue générale des chemins de fer, août, p. 113.

CAYLA (M.). — **Elargissement du viaduc** de Meudon. (1 700 mots & fig.)

1936 **385 .113 (.61)**

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CLOSSET (F.). — Les **chemins de fer de Tunisie** de 1933 à 1935. (2 500 mots et fig.)

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SPRONCK (R.). — Mesure et prévision des **actions du vent sur les constructions.** (4 300 mots & fig.)

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1936 **625 .14 & 625 .17**

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FLAMENT (H.). — La **voie ferrée.** Sa constitution. Son entretien. (3 800 mots & fig.)

1936 **625 .6**

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KANDAOUROFF (P.). — Comparaison des **résultats économiques d'exploitation** des tramways et des auto- bus de divers modes de propulsion. (1 500 mots & fig.)

1936 **656 .222.5 (.44)**

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La **nouvelle formule des indicateurs Chaix.** (3 000 mots & fig.)

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1936 **625 .6 (.43)**
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TEUBERT. — Die **Strassenbahnen und Bahnen besonderer Bauart** im Deutschen Reiche im Jahre 1933. (7 200 Wörter.)

1936 **656 .213 (.43)**
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SEEGER. — Die neuen **Hafenbahnverträge** der badischen staatlichen Häfen von Mannheim, Rheinau und Kehl. (4 200 Wörter & Abb.)

1936 **656 (.73)**
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BERCHTOLD (W.). — Die Massnahmen zur **Sanierung des Verkehrs** in den Vereinigten Staaten von Amerika. (15 000 Wörter.)

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SMIRNOW. — Der gegenwärtige Stand der **russischen Eisenbahnwirtschaft**. (5 500 Wörter & 1 Karte.)

1936 **385 (.498)**
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SAUTER. — Die Ausführung des **Sanierungsprogramms** der rumänischen Bahnen 1932-1935. (4 200 Wörter.)

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MÜLLER-HILLEBRAND. — Die **Reichsbahn auf der Ausstellung** « Deutschland ». (6 500 Wörter & Abb.)

1936 **656 .235 (.43)**
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BASTIANSEN. — Die Neuordnung des Entfernungszeigers der deutschen **Eisenbahn-Gütertarife**. (800 Wörter.)

1936 **614 (.43)**
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KNOCHE. — Die Mitarbeit der **Reichsbahn-Bezirksfürsorge** in der deutschen Volksfürsorge. (3 600 Wörter.)

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WEYLAND (F.). — **Triebwagen- und Kleinlokomotiv-Ladeanlagen** und ihre wirtschaftliche Ausnutzung durch Schnelladung von Speicherfahrzeugen. (1 400 Wörter & Abb.)

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KLEINOW (W.). — **1 Do 1-Reichsbahnschnellzuglokomotive** Reihe E 18. (10 000 Wörter & Abb.)

1936 **621 .33**
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MICHEL (O.). — **Einheitliche Bezeichnung** der Lokomotiven und Triebwagen. (2 400 Wörter & Abb.)

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Elektrische Bahnen, Juni, S. 149.
SCHRÖDER (W.). — **Bo-Bo-Güterzuglokomotive** 1 500 V-Gleichstrom für die Oeste de Minas-Bahn i Brasilien. (2 500 Wörter & Abb.)

1936 **621 .335 (.47**
Elektrische Bahnen, Juni, S. 156.
Die erste **elektrische Schnellzuglokomotive PB 21** d Sowjetunion. (1 000 Wörter.)

1936 **621 .33 (.489**
Elektrische Bahnen, Juli, S. 159.
FOGTMANN (H. W.). — Die **Elektrisierung** d Nahverkehrs von Kopenhagen. (5 800 Wörter & Abb

1936 **621 .33 (.436**
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TEICHTMEISTER (J.). — Der **elektrische Zugbetrie** bei den Österreichischen Bundesbahnen im Jahre 193 (2 400 Wörter & Abb.)

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WAGNER (R. P.). — Eine schwere **1 E 1-Sandbahn Tenderlokomotive**. (4 500 Wörter & Abb.)

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HERRMANN (M.). — Die **Messung der gegenseitige Höhenlage der Fahrschienen** in dem Oberbaumesswage der Deutschen Reichsbahn. (2 500 Wörter & Abb.)

1936 **625 .144**
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BLOSS. — Der **Übergangsbogen** mit geschwungene Überhöhungsrampe. (700 Wörter & Abb.)

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[EIER (H.). — **Eigenspannungen** in Eisenbahn-enen. (7 000 Wörter, 3 Tafeln & Abb.)

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1936 **625 .5 (.494)**
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UBIN (A.). — Die **Seilschwebebahn** auf den Säntis. 00 Wörter & Abb.)

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1936 **621 .392 & 669**
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1936 **656 .259**
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ROST (R.). — Der **Riegelhandverschluss.** (1 500 rter & Abb.)

1936 **656 .256 (.43)**
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IENHARD. — Neue **Sicherungsanlagen** für Bahnhof terbach (Elsass). (2 500 Wörter & Abb.)

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1936 **656**
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1936 **385. (09 (.41 + .42)**
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1936 **621 .13 (.43) & 625 .2 (.43)**
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BAISCH. — Die **Fahrzeuge der Deutschen Reichsbahn** auf der Jahrhundertausstellung, gesehen vom Architekten. (4 500 Wörter & Abb.)

1936 **625 .4 (.43)**
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Berliner Nordsüd-S-Bahn. (900 Wörter & Abb.)

1936 **385 (.57)**
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SALLER. — Eine **neue Bahn** im Fernen Sowjet-Osten. (500 Wörter & 1 Karte.)

1936 **656 (.481) & 656 .231 (.481)**
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LOKEN. — Neue Anpassung des norwegischen **Gütertarifs** an die Wettbewerbslage. (1 900 Wörter & Abb.)

1936 **385. (06.4 (.43)**
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MERRITT (H. E.). — The art of **gear design.** (7 200 words & fig.) (To be continued.)

1936 **624 .51 (.73)**
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The Golden Gate **Bridge,** No. II (8 800 words & fig.)

1936 **621 .33**
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Main-line electrification abroad. No. III. (1 400 words & 3 tables.)

1936 **656 .212.6 (.42)**
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Jarrow Staith **(coal loading towers).** (1 500 words & fig.)

1936 **697**
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TAYLOR (W. T.). — **Water vapour (vacuum) refrigeration.** (7 900 words, 4 tables & fig.)

1936 **624 .51 (.42)**
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Chelsea bridge. (2 700 words & fig.)

1936 **621 .132.1 (.68)**
Engineer, No. 4204, August 7, p. 141.
Latest South African **locomotives.** (1 300 words & fig.)

1936 **621 .43 (.42)**
Engineer, No. 4205, August 14, p. 156.
Railcar with pneumatic tyres. (2 900 words & fig.)

1936 **624 (.42)**
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The Kincardine-on-**Forth bridge.** (2 600 words & fig.) & fig.)

1936 **621 .132.3 (.71)**
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Canadian National Railways **streamlined locomotive.** (500 words & fig.)

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1936 **621 .85 & 65**
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Rapid-hardening Portland cement. (1 000 words.)

1936 **656 .212.6 (.42)**
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1936 **621 .39 & 621 .94**
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Electrically-operated milling machine attachment. (700 words & fig.)

1936 **624 .1 & 721 .3**
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Tests on large columns. (2 800 words.)

1936 **62. (01 & 662**
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BIRD (A. L.) & BAUER (S. G.). — The measurement of the quality of **high-speed oil engine fuels.** (2 000 words & fig.)

1936 **621 .43 (.42**
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56-seater pneumatic-tyred petrol-driven railcar. (3 60 words & fig.) (To be continued.)

1936 **621 .9 (.42**
Engineering, No. 3683, August 14, p. 170.
Automatic stopping device for four-spindle bar lath (900 words & fig.)

1936 **69**
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1936 **347 .763 (.7**
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WORLEY (J. S.). — **Regulating transport** — V Offland transport dodges reformers. (3 600 words.)

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NORTH (W. G.). — **Convenient concrete table** contractors' use. (500 words & fig.)

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ILLINGWORTH (V. R.). — **Deterioration of st** tures in sea water. (3 000 words & fig.)

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1936 **656 .28 (0**
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1936 **656 .23 (.42)**
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tabilising rates by rail and road. — Views of in-rial transport managers. (1 900 words.)

1936 **621 .338 (.42)**
lern Transport, No. 905, July 18, p. 5.
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1936 **385 .1 (.94)**
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ighway development in Australia. — Control in tralia. (1 400 words.)

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lern Transport, No. 906, July 25, p. 3.
argest suspension bridge in the British Empire. n's Gate Bridge, Vancouver Harbour. (750 words &)

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1936 **621 .132.8 (.73)**
dern Transport, No. 907, August 1, p. 3.
Novelty in railway coach planning. — Latest New k Central train. (1 200 words & fig.)

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Electric traction in Natal. — British built locomotives. (800 words & fig.

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Locomotives for German mountain railway. — Flexible ten-coupled units. (1 700 words & fig.)

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Railway Age, No. 2, July 11, p. 50.
New York Central builds distinctive streamline train. (7 600 words, 2 tables & fig.)

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Superintendent discuss high-speed passenger trains. (3 700 words & 1 table.)

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GARDNER (T. H.). — Florida East Coast erects first all-welded bascule span. (3 700 words & fig.)

1936 **621 .132.7 (.73)**
Railway Age, No. 3, July 18, p. 104.
Union Railroad receives transfer locomotives from Baldwin. (650 words, 1 table & fig.)

1936 **621 .139 (.73) & 625 .27 (.73)**
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Railroad Supply Departments hold annual meeting (Scrap costs and simplification of materials, etc...). (14 000 words & fig.)

1936 **62. (01 (.73) & 625 .252 (.73)**
Railway Age, No. 4, July 25, p. 138.
New brake-shoe testing machine in Sargent laboratory. (1 400 words & fig.)

1936 **621 .33 (.73)**
Railway Age, No. 4, July 25, p. 143.
Federal Power Commission's National Power survey suggests electrification on 20 railroads. (1 600 words.)

1936 **656 .1 (.73)**
Railway Age, No. 4, July 25, p. 150.
New Haven **bus and truck subsidiaries** work together. (1 400 words, 1 table & fig.)

1936 **656 (.73)**
Railway Age, No. 4, July 25, p. 153.
Winning back merchandise traffic (by careful study and revision of schedules and by rail highway co-ordination). — Texas & Pacific Railway. (1 700 words & fig.)

1936 **656 .225 (.73) & 656 .261 (.73)**
Railway Age, No. 4, July 25, p. 155.
A new type of **container.** (500 words & fig.)

1936 **625 .242 (.73) & 691 (.73)**
Railway Age, No. 6, August 8, p. 202.
Does gum wood make good **ties ?** (5 300 words & fig.)

1936 **656 .23 (.73)**
Railway Age, No. 6, August 8, p. 207.
LISMAN (F. J.). — Forestalling moves of « other fellow » a necessity in **price competition.** (5 800 words.)

1936 **656 .212.6 (.73) & 656 .225 (.73)**
Railway Age, No. 6, August 8, p. 211.
Speed and efficiency in handling merchandise. Part II. (2 200 words & fig.)

1936 **625 .213 & 625 .215**
Railway Age, No. 6, August 8, p. 214.
GIESL (A.). — **Riding qualities of passenger cars.** — Knowledge of harmonic vibrations essential for correct design — why European roads are discontinuing American type trucks. (1 500 words & fig.)

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1936 **625 .242**
Railway Engineering & Maintenance, July, p. 412.
Does protection of **ties** end with treatment ? (800 words & fig.)

1936 **625 .13 (.73)**
Railway Engineering & Maintenance, July, p. 414.
CLEMENTS (M. F.). — Lining a **tunnel** with precast concrete blocks. (1 400 words & fig.)

1936 **625 .13 (.73)**
Railway Engineering & Maintenance, July, p. 416.
Tools speed **bridge** repair program on the Erie. (3 900 words & fig.)

1936 **385 .586 (.73)**
Railway Engineering & Maintenance, July, p. 421.
Work equipment — how to select and train operators. (1 400 words & fig.)

1936 **625 .175 (.8**
Railway Engineering & Maintenance, July, p. 423.
Motors cars improve **gang organization** on Argenti Railway. (2 000 words & fig.)

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1936 **621 .13**
Railway Gazette, No. 5, July 31, p. 177.
The **turbine locomotive** criticised. (900 words.)

1936 **656 .222.1 (.4**
Railway Gazette, No. 5, July 31, p. 184.
The **fastest trains** in Great Britain. (500 words & tables.)

1936 **313 : 656 .23 (.4**
Railway Gazette, No. 5, July 31, p. 185.
British Railway statistics. April 1936, as compa with April 1935, compiled from the Ministry of Tra port Statement No. 197. (2 tables.)

1936 **625 .215 (.43) & 625 .619 (.4**
Railway Gazette, No. 5, July 31, p. 186.
Key control for points on light railways. The A germann apparatus used on the German State Railwa (1 200 words & fig.)

1936 **621 .138.1 (.42) & 625 .154 (.4**
Railway Gazette, No. 5, July 31, p. 188.
Turning locomotives by power from brake appara on the L. N. E. Ry. (700 words & fig.)

1936 **621 .132.3 (.4**
Railway Gazette, No. 5, July 31, p. 190.
New standard **2-8-2 type locomotive** in Japan. (words & fig.)

1936 **656 .212.6 (.4**
Railway Gazette, No. 5, July 31, p. 202.
The new **coal shipping staith** at Jarrow. (1 600 word

1936 **625 .1 (.45) & 656 .211 (.4**
Railway Gazette, No. 6, August 7, p. 223.
The Bologna Direttissima and Florence new **stati** (2 500 words & fig.)

1936 **621 .132.3 (.**
Railway Gazette, No. 6, August 7, p. 229.
New C. P. R. **streamlined 4-4-4 locomotives.** (words & fig.)

1936 **656 .23 (.4**
Railway Gazette, No. 7, August 14, p. 262.
Rating of railways. (Development of railway val tion for rating.) (1 800 words & 1 table.)

1936 **621 .134.2 (.4**
Railway Gazette, No. 7, August 14, p. 265.
COOK (K. J.). — Machining a locomotive va **Gear** — I. — Operations involved in the production Stephenson link motion for G. W. R. « Hall » cl express engines. (3 000 words & fig.)

1936 **621 .43 (.42)**

Diesel Ry. Traction, p. 242, Supplt. to Ry. Gazette, August 7.

A new British **diesel-locomotive.** — 275 b. h. p. unit with pre-selective mechanical transmission. (1 000 words & fig.)

1936 **621 .43 (.493) & 656 .222.2 (.493)**

Diesel Ry. Traction, p. 244, Supplt. to Ry. Gazette, August 7.

Multi-stop **Diesel services** in Belgium. (350 words, 2 tables & fig.)

1936 **621 .43 (.43)**

Diesel Ry. Traction, p. 246, Supplt. to Ry. Gazette, August 7.

Supercharged railcars for the German State Railways. (450 words & fig.)

1936 **621 .43 (.73)**

Diesel Ry. Traction, p. 247, Supplt. to Ry. Gazette, August 7.

Largest single-unit Diesel locomotive (Illinois Central RRd.). (300 words & fig.)

1936 **621 .43 (.42)**

Diesel Ry. Traction, p. 248, Supplt. to Ry. Gazette, August 7.

Big **Diesel car** introduced in Northern Ireland. 260 b. h. p. vehicle for trailer haulage. (200 words & fig.)

1936 **621 .43 (.460)**

Diesel Ry. Traction, p. 249, Supplt. to Ry. Gazette, August 7.

Spanish railcar performance 100 per cent, railcar operation on small line. (400 words & 2 tables.)

1936 **621 .43 (.73)**

Diesel Ry, Traction, p. 250, Supplt. to Ry. Gazette, August 7.

City of Denver trains take up service. (600 words & fig.)

Railway Magazine. (London.)

1936 **656 .222.1 (.43)**

Railway Magazine, August, p. 79.

ALLEN (C. J.). — **High speed** in Germany. (3 500 words, 4 tables & fig.)

1936 **656 .222.1 (.42)**

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1936 **385. (09 (.42)**

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DONCASTER (C. M.). — **The Whitby & Pickering Railway.** (2 200 words & fig.)

1936 **621 .132.3 (.42)**

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New L. N. E. Ry. locomotives. (700 words & fig.)

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NOCK (O. S.). — **The locomotives of the L. N. W. Ry. 1897-1922.** — Part I, 1897-1902. (3 300 words & fig.)

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Fifteenth Annual Meeting of the Mechanical Division, A. A. R. — Electric rolling stock. — Lubrification of cars and locomotives. — Prices for labor and materials. — Brakes and brake equipment. — Air conditioning and equipment lighting. — Safety appliances. — Specifications for materials. — Loading rules. — Arbitration committee. — Economies in cost of billing for foreign freight-car repairs. — Couplers and draft gears. — Car construction. — Locomotive construction. — Tank cars. — Wheels.

1936 **625 .232 (.73)**

Railway Mechanical Engineer, August, p. 331.

New York Central train « The Mercury ». (5 600 words & fig.)

1936 **621 .133.4 (.73) & 621 .133.5 (.73)**

Railway Mechanical Engineer, August, p. 339.

Locomotive front-end arrangement. (Abstract of a sub-committee report included in the general report of the committee on Locomotive Construction at the meeting of the Mechanical Division of the A. A. R., Chicago, June 25 and 26, 1936. (6 300 words & fig.)

1936 **625 .212 (.73)**

Railway Mechanical Engineer, August, p. 365.

DORNER (F. R.). — With the car foremen and inspectors finding the average life of **freight car wheels.** (2 000 words & fig.)

1936 **625 .234 (.73)**

Railway Mechanical Engineer, August, p. 366.

Air-conditioned road and laboratory tests. (1 800 words & fig.)

South African Railways and Harbours. (Johannesburg.)

1936 **621 .392 (.68) & 625 .246 (.68)**

South African Railways & Harbours, July, p. 857.

Mechanical Department's activities. How 2 000 **steel wagons,** ES 4 type, were built in record time. (2 000 words & fig.)

1936 **621 .335 (.68)**

South African Railways & Harbours, July, p. 873.

New **electric locomotives** for Natal. (950 words & fig.)

The Commercial & Technical Journal. (Calcutta.)

1936 **625 .214**

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The reclamation of used lubricating oil and streamline filtration. (2 200 words.)

1936 **621 .392 & 625 .2**

The Commercial & Techn. Journal (Calcutta), July, p. 14.

Welding as applied to vehicular structures. (5 200 words.)

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1936 **621 .43**

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The **oil engine** for rail transport. (2 200 words.)

1936 **621 .132.5 (.73)**

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2-8-4 type locomotive, Detroit, Toledo & Ironton Railroad. (700 words & fig.)

1936 **621 .132.3**

The Locomotive, July 15, p. 209.

The Werry **high speed locomotive.** (900 words & fig.)

1936 **625 .232 (.73)**

The Locomotive, July 15, p. 210.

Stainless steel car, A. T. & S. Fe Railway. (600 words & fig.)

1936 **385 .4 (.42)**

The Locomotive, July 15, p. 211.

Position of the locomotive engineer in **railway organisation.** (3 700 words & fig.)

1936 **621 .133.2 (.44)**

The Locomotive, July 15, p. 214.

Welded locomotive firebox, French State Railways. (450 words.)

1936 **625 .215 (.66)**

The Locomotive, July 15, p. 217.

Sheffied-Twinberrow **bogies,** Gold Coast and Nigerian Rys. (700 words & fig.)

1936 **625 .234 (.94)**

The Locomotive, July 15, p. 219.

Air-conditioning for the Commonwealth Railways. (1 200 words & fig.)

1936 **621 .43 (.489)**

The Locomotive. July 15, p. 225.

Frichs **Diesel locomotive for local service,** Aalborg Railway, Denmark. (1 200 words & fig.)

1936 **621 .8**

The Locomotive, July 15, p. 226.

CARLISLE (W. E.). — **Jigs, fixtures, and notes o production.** (350 words & fig.) (To be continued.)

The Oil Engine. (London.)

1936 **621 .43 (.42**

The Oil Engine, August, p. 99.

A 70 m. p. h. **railcar** for Northern Ireland. (400 word & fig.)

1936 **621 .43 (.493**

The Oil Engine, August, p. 101.

Belgian **Diesel express trains.** — The Carels S. E. M equipment. (1 100 words & fig.)

1936 **621 .43 (.42**

The Oil Engine, August, p. 109.

A high-speed **railcar** two-stroke engine. — An Atl 200 b. h. p. 1 800 r. p. m. Scavenge-blower type pow unit, designed for electrical transmission. (600 wor & fig.)

1936 **385 .114 (.73) & 621 .43 (.7**

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MANN (Chas. F. A.). — The **operating costs** of seven-car train. (700 words.)

1936 **621 .43 & 621 .**

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WATSON (J. D.). — **Lubrication** in the Diesel engi (1 100 words & fig.)

1936 **621 .43 (.4**

The Oil Engine, August, p. 117.

A 600 b. h. p. pressure-charged power unit for ra way traction. (900 words & fig.)

1936 **621 .43 (.4**

The Oil Engine, August, p. 118.

The first Vulcan-Frichs **mechanical shunter.** (1 2 words & fig.)

Transit Journal. (New York.)

1936 **621 .33 (.73) & 625 .62 (.7**

Transit Journal, July, p. 216.

Tomorrow's street car. (1 400 words & fig.)

1936 **621 .33 (.73) & 625 .215 (.7**

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Rubber springing characterizes truck design of P. C. C. car (U. S. A.). (1 600 words & fig.)

1936 **621 .338 (.7**

Transit Journal, July, p. 224.

The new motors, control and brakes of the P. C. electric car (U. S. A.). (1 600 words & fig.)

1936 621 .338 (.73)
ansit Journal, July, p. 227.
New objectives met in P. C. C. **car body.** (1 800 words fig.)

1936 621 .338 (.73)
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In Bulgarian.

(= 91.881)

Spisanie. (Sofia.)

1936 625 .233 (.497.2)
isanie, February, p. 5.
BARNEV. — **Gas lighting of carriages** on the Bulgan State Railways. (11 400 words & fig.)

In Spanish.

Revista de Obras Públicas. (Madrid.)

1936 385 (.460) & 656 .213 (.460)
vista de Obras Públicas, 15 de julio, p. 266.
JCELAY (J. de). — **Nuevos ferrocarriles en relación el tráfico marítimo** y las obras de los puertos. (2 700 abras & 2 mapas.)

1936 385 .15 (.460)
vista de Obras Públicas, 15 de julio, p. 271.
ODERCH (E.). — La **incautación por el Estado** de Ferrocarriles Andaluces. (1 600 palabras.)

In Italian.

La tecnica professionale. (Firenze.)

1936 625 .251 (.4)
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ASOLI (M.). — L'applicazione del **freno continuo** treni merci delle ferrovie europee. (3 300 parole & .)

1936 621 .43
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AMATI (G.). — Nozioni sui **combustibili usati nei tori a combustione interna.** (5 700 parole & fig.)

Rivista tecnica delle ferrovie italiane. (Roma.)

1936 656 .256.3
vista tecnica delle ferrovie italiane, 15 agosto, p. 65.
MARIANI (E.) & MINUCCIANI (G.). — Dispositivi impianti di **blocco automatico.** (4 500 parole & fig.)

1936 625 .13
Rivista tecnica delle ferrovie italiane, 15 agosto, p. 77.
CORINI (F.). — Statica dei rivestimenti delle **gallerie.** (7 500 parole & fig.)

1936 656 (.63)
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Il problema dei **trasporti** in Etiopia. (2 900 parole & fig.)

In Dutch.

De Ingenieur. (Den Haag.)

1936 656 .254
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SCHEFFER (J. M. G.). — De **automatische treinbeveiliging.** (6 200 woorden & fig.)

1936 385 (.492)
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Beschouwingen over de **reorganisatie** der Nederlandsche Spoorwegen. (1 200 woorden.)

Spoor- en Tramwegen. (Utrecht.)

1936 385. (09 (.492)
Spoor- en Tramwegen, N^r^ 15, 21 Juli, p. 345.
VAN SETTEN (D.). — De **Spoorwegen** in de Haarlemmermeer. (3 600 woorden & 1 kaart.) (Wordt vervolgd.)

1936 385 .113 (.492)
Spoor- en Tramwegen, N^r^ 15, 21 Juli, p. 348.
De **Nederlandsche Spoorwegen** in 1935. (1 500 woorden, 3 tabellen & fig.)

1936 656 .212 (.492)
Spoor- en Tramwegen, N^r^ 16, 4 Augustus, p. 369.
BARDET (J. D. M.). — De **grondwerken** in verband met de verbetering van de verkeerstoestanden te Amsterdam-Oost. (3 600 woorden & fig.)

In Polish.

(= 91.885)

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1936 385 .4 (.438) = 91 .885
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CYWINSKI (B.). — **Réforme de la gestion** des chemins de fer polonais. (10 000 mots & fig.)

1936 625 .142.3 = 91 .885
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KRÜGER (A. W.). — **Traverses métalliques** et progrès réalisés dans leur fabrication. (6 600 mots & fig.)

In Czech.

(= 91.886)

Casopis pro železnični právo a politiku. (Praha.)

1936 **656 (.44) = 91 .886**

Casapis pro zeleznicni právo a politiku, No. 3, p. 33.

WEIL. — **Rail an road co-ordination** in France. (11 200 words.) (To be continued.)

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1936 **385 .114 = 91 .886**

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Zprávy železničních inženýrů. (Praha)

1936 **625 .253 (.437) = 91 .886**

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KUDZNA. — Completion of the work of fitting **goods wagons** with the compressed **air brake.** (5 500 words.)

1936 **625 .144.2 = 91 .886**

Zpravy zeleznicnich inzenyru, No. 1, p. 12; No. 2, p. 22.

DEYL. — Repegging existing **railway curves.** (6 050 words & fig.)

1936 **385. (09 (.47) = 91 .886**

Zpravy zeleznicnich inzenyru, No. 2, p. 17.

NOVICKY. — **Railways** in Czarist Russia and in the U. R. S. S. (5 500 words.)

1936 **625 .143.2 (06 = 91 .886**

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ZAVADIL. — Third International Congress for Testing Materials intended for **rail** manufacturing. (Budapest, 1935.) (2 750 words.)

1936 **656 .257 = 91 .886**

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SEMPACH. — **Relations between play in control levers and length of transmission wires.** (2 200 words.)

1936 **625 .173 = 91 .88**

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VAVERKA. — Should **track renewal and maint nance** work be carried out by railway forces or l contracted out ? (5 500 words.)

1936 **621 .132.3 = 91 .88**

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1936 **625 .251 = 91 .8**

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ZOPF. — **Braking distances.** (4 400 words & diagr

1936 **625 .142.2 = 91 .8**

Zpravy zeleznicnich inzenyru, No. 4, p. 60.

ZALCIK. — When should trees used for **railwa sleepers** be felled ? (2 200 words.)

In Jugoslav.

(= 91.882)

Saobračajni Pregled. (Beograd.)

1936 **656 .222.1 = 91 .8**

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1936 **621 .131.3 (.497.1) = 91 .8**

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JOVANOVIC. — **Dynamometer cars** of the Jugos State Railways. (4 050 words & fig.)

1936 **621 .33 = 91 .8**

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RUZIK. — **Railway electrification.** (Conclude (5 400 words & fig.)

1936 **625 .114 = 91 .8**

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MICHEJEV & SIMIC. — Quick method for calcu ting the importance of **earthworks** based on the gene survey of a railway line. I. Theory. (To be continue (4 950 words & fig.)

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[016. 385. (02]

I. — BOOKS.

In French.

1936 621 .13 (02

IGERIE (R.) et DEVERNAY (E.).

La locomotive actuelle.

Paris, Dunod, 92, rue Bonaparte. 1 volume, 607 pages 552 figures. (Prix : 54 fr. français.)

In German.

1936 624 .2

NGER (G.).

Zehnteilige Einflusslinien für den durchlaufenden räger.

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1936 631 .392

Aus Theorie und Praxis der Elektroschweissung.

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Heft 2 : **Die Schrumpfung geschweisster Stumpfnähte,** on Richard MALISIUS.

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Heft 3 und 4 : **Schweissen im Hebezeugbau,** von ichard HÄNCHEN.

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1936 656 .1 (.43)

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1936 665 .882

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1936 537 .7

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1936 621 .7 & 621 .9

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1936 **614 .7**

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1936 **62. (01**

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Copies obtainable from the Author.

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1936 **691**

Annales des ponts et chaussées, juillet, p. 11.

FERET (R.). — **Porosité et perméabilité des bétons.** (7 800 mots & fig.)

Annales des travaux publics de Belgique. (Bruxelles.)

1936 **624 .32 (.4**

Ann. des travaux publics de Belgique, août, p. 385.

ELEGEERT. — **La reconstruction du pont d'Ande sur la Meuse.** — I. Déplacement du pont actuel. (3 mots.)

Arts et Métiers. (Paris.)

1936 **621 .**

Arts et Métiers, août, p. 164.

MATHIEU (M.). — **Le calcul de la consommat d'énergie dans la soudure électrique par résistar** (2 500 mots.)

Bulletin de la Société d'encouragement pour l'industrie nationale. (Paris.)

1936 **621 .9**

Bull. de la Sté d'encouragement pour l'indust. nationale, août-septembre, p. 469.

MASSOT (P.). — Les gammes de vitesses des **machines-outils.** (9 000 mots & fig.)

1936 **669 .1**

Bull. de la Sté d'encouragement pour l'indust. nationale, août-septembre, p. 526.

BALLAY (M.). — Etat actuel des **alliages légers** et ultra-légers. Les alliages de glucinium. (4 800 mots & fig.)

1936 **669 .1**

Bull. de la Sté d'encouragement pour l'indust. nationale, août-septembre, p. 545.

GALIBOURG (J.). — Les tendances actuelles des **aciers spéciaux.** (8 300 mots & fig.)

Bulletin de l'Union internationale des chemins de fer. (Paris.)

1936 **385 .113 (.42)**

Bull. de l'Union intern. des ch. de fer, juin, p. 189.

SHERRINGTON (C. E. R.). — Les **quatre grandes compagnies de chemins de fer** de Grande-Bretagne pendant l'exercice 1935. (7 800 mots, 23 tableaux.)

1936 **656 (.44)**

Bull. de l'Union intern. des ch. de fer, juin, p. 201.

La **coordination** en France des transports ferroviaires et aériens. (3 500 mots.)

1936 **656 (.4)**

Bull. de l'Union intern. des ch. de fer, juillet-août, p. 256.

Rapport des Chemins de fer allemands et des Chemins de fer Fédéraux suisses sur la question : **concurrence et coopération** en trafics voyageurs et marchandises entre chemin de fer et automobile (juin 1936). (15 200 mots.)

1936 **385 .113 (.71)**

Bull. de l'Union intern. des ch. de fer, septembre, p. 281.

SHERRINGTON (C. E. R.). — Les deux **grands réseaux du Canada** en 1934 et 1935. (6 000 mots, 9 tableaux & fig.)

1936 **385 .113 (.493)**

Bull. de l'Union intern. des ch. de fer, septembre, p. 290.

La **Société Nationale des chemins de fer belges** en 1935. (5 400 mots.)

1936 **385 .113 (.494)**

Bull. de l'Union intern. des ch. de fer, septembre, p. 296.

Les **Chemins de fer fédéraux suisses** en 1935. (5 500 mots.)

Bulletin des transports internationaux par chemins de fer. (Berne.)

1936 **385 .62 & 385 .63**

Bull. des transp. intern. par ch. de fer, août, p. 351.

EGER (M.). — La question de l'entrée en vigueur des nouvelles **Conventions.** (2 500 mots.)

1936 **313 .385 (.436)**

Bull. des transp. intern. par ch. de fer, août, p. 383.

Statistique des chemins de fer autrichiens pour les années 1933 et 1934. (1 200 mots.)

1936 **313 .385 (.47.42)**

Bull. des transp. intern. par ch. de fer, septembre, p. 428.

Statistique des Chemins de fer de l'Etat d'Esthonie pour 1933-34 et 1934-35. (400 mots.)

Bulletin technique de la Suisse romande. (Vevey.)

1936 **691**

Bull. techn. de la Suisse romande, n° 17, 15 août, p. 202.

L'emploi du « Plastiment » en vue d'améliorer la qualité des **bétons.** (1 200 mots & fig.)

Chronique des Transports. (Paris.)

1936 **656 .225 (.44)**

Chronique des transports, n° 17, 10 septembre, p. 2.

Un nouveau progrès dans l'exploitation commerciale des chemins de fer français : les **services express.** (1 100 mots.)

1936 **385 .1 (.44)**

Chronique des transports, n° 18, 25 septembre, p. 2.

Ce qu'ont fait les grands réseaux pour réduire leur **déficit.** (3 200 mots.)

Génie civil. (Paris.)

1936 **691**

Génie civil, n° 2820, 29 août, p. 184.

KUNZ (C.), FONTANELLAZ (E.) & HALLER (P.). — **Traitement électrique du béton,** pour éviter la gelée, et permettre le bétonnage pendant l'hiver. (2 200 mots & fig.)

1936 **625 .143.1**

Génie civil, n° 2820, 29 août, p. 186.

LARTHOMAS (P.). — Comparaison entre la **voie Vignole** et la **voie à double champignon.** (4 200 mots.)

1936 **691**

Génie civil, n° 2821, 5 septembre, p. 204.

KUNZ (C.), FONTANELLAZ (E.) & HALLER (P.). — **Traitement électrique du béton** pour éviter la gelée et permettre le bétonnage pendant l'hiver. (3 400 mots & fig.)

1936 **621 .43**

Génie civil, n° 2821, 5 septembre, p. 208.

L'usure des cylindres dans les **moteurs Diesel.** (1 100 mots & fig.)

1936 **621 .132.8 (.65)**

Génie civil, n° 2822, 12 septembre, p. 217.

MARTIN (H.). — Les nouvelles **locomotives Garratt** des Chemins de fer algériens. (3 400 mots & fig.)

1936 **62. (01 & 624 .2**

Génie civil, n° 2822, 12 septembre, p. 220; n° 2823, 19 septembre, p. 244.

PODOLSKY (J.). — Formule générale pour le calcul de la ligne élastique d'une **poutre droite.** (4 500 mots & fig.)

1936 **624 (.43)**

Génie civil, n° 2822, 12 septembre, p. 231.

Les cinq nouveaux **ponts métalliques,** construits ou en construction, sur le Rhin allemand. (800 mots & fig.)

1936 **656 .211.7 (.4)**

Génie civil, n° 2823, 19 septembre, p. 237.

CAUFOURIER (P.). — Les **ferry-boats** entre la Grande-Bretagne et le Continent. (5 500 mots & fig.)

1936 **691**

Génie civil, N° 2823, 19 septembre, p. 241.

LEMAIRE (E.). — La soudure et la reprise du béton dans les **travaux en béton armé.** (4 200 mots & fig.)

L'Allégement dans les transports. (Lucerne.)

1936 **625 .62 (.45) & 669 (.45)**

L'Allégement dans les transports, septembre-octobre, p. 114.

FERRARI (R.). — Nouvelle **motrice en métaux légers** des Tramways de Milan. (3 400 mots & fig.)

La Traction électrique. (Paris)

1936 **621 .33**

La Traction Electrique, juin, p. E. 221.

DE KOTSCHUBEY (N.). — **Redresseurs à vapeur de mercure** dans les installations de grande traction électrique. (3 700 mots & fig.)

1936 **621 .43 (.493)**

La Traction Electrique, juin, p. E. 229.

HENNIG (E.). — Les **automotrices Diesel-électriques** de la Société Nationale des Chemins de fer belges. (6 000 mots & fig.) (A suivre.)

Les Chemins de fer et les Tramways. (Paris.)

1936 **621 .43**

Les Chemins de fer et les Tramways, août-septembre-octobre, p. 152.

GURLEY (F. C.). — **Trains à grande vitesse** actionnés par moteurs à huile lourde. (2 500 mots.)

1936 **621 .335 (.494**

Les Chemins de fer et les Tramways, août-septembr octobre, p. 153.

L'**automotrice légère** Cc 2/4, n° 787 de la Compagn du Chemin de fer des Alpes bernoises. (900 mots.)

1936 **621 .4**

Les Chemins de fer et les Tramways, août-septembre octobre, p. 154.

Transmission électrique pour véhicules « Système d Contrôle General Electric ». (1 400 mots & fig.)

1936 **621 .4**

Les Chemins de fer et les Tramways, août-septembre octobre, p, 156.

OPATOWSKI (I.). — La perte de vitesse des **automotrices à transmission mécanique** au cours du chan gement de rapport de transmission. (4 600 mots.)

1936 **625 .23 (.65)**

Les Chemins de fer et les Tramways, août-septembre octobre, p. 159.

Voitures métalliques des Chemins de fer algériens (2 600 mots.)

1936 **621 .131.1**

Les Chemins de fer et les Tramways, août-septembre octobre, p. 161.

Augmentation de **puissance des locomotives à vapeur** (1 600 mots & fig.)

1936 **621 .133.7**

Les Chemins de fer et les Tramways, août-septembre octobre, p. 163.

Injecteur avec tiroir d'arrêt d'eau, particulièrement pour locomotives. (1 100 mots & fig.)

1936 **625 .234**

Les Chemins de fer et les Tramways, août-septembre octobre, p. 164.

Dispositif de **chauffage électrique** des trains réglable par variation de la résistance au moyen d'un rhéostat automatique. (1 400 mots & fig.)

1936 **625 .143.4**

Les Chemins de fer et les Tramways, août-septembre octobre, p. 165.

Eclissage de rails perfectionné. (1 300 mots & fig.)

Revue générale des chemins de fer. (Paris.)

1936 **388 (.42)**

Revue générale des chemins de fer, septembre, p. 137.

DAUTRY. — La formule anglaise des « **Public Trusts** » appliquée à la gestion de grands services publics. (13 900 mots & fig.)

1936 **621 .133.5 (.44)**

Revue générale des chemins de fer, septembre, p. 164.

LEDARD. — Perfectionnements apportés par la Compagnie du Chemin de fer du Nord aux **échappements** de ses locomotives. (3 600 mots & fig.)

1936 **625 .13 (.44)**

Revue générale des chemins de fer, septembre, p. 172.

CAYLA (M.). — **Reconstruction de l'ouvrage** dit « Du Clos Montholon » à Clamart. (1 400 mots & fig.)

1936 **625 .234 (.44)**

Revue générale des chemins de fer, septembre, p. 177.

LEVY (J.). — Essais des **voitures de l'Etat chauffées par l'air soufflé** sur les réseaux de l'Etat, de l'Alsace-Lorraine et du P. O.-Midi. (800 mots & fig.)

1936 **385 .113 (.65)**

Revue générale des chemins de fer, septembre, p. 179.

CLOSSET (P.). — Les **Chemins de fer algériens** de 1933 à 1935. (3 500 mots & fig.)

Revue universelle des Mines. (Liége.)

1936 **624 .2**

Revue universelle des mines, septembre, p. 357.

LELOUP (L.). — Des déformations dues au cisaillement dans les **poutres** fléchies. (4 400 mots & fig.)

1936 **669 .1**

Revue universelle des mines, septembre, p. 365.

GORDENNE (U.). — Les **aciers** à faible teneur en cuivre et leur résistance à la corrosion. (Essais effectués par la S. A. d'Ougrée-Marihaye.) (1 300 mots, 4 tableaux & fig.)

Revue universelle des transports et des communications. (Paris.)

1936 **621 .13**

Revue universelle des transp. et des communic., mai-juin, p. C. 119.

Les progrès récents de la **locomotive à vapeur.** (1 800 mots & fig.)

1936 **621 .131.3**

Revue universelle des transp. et des communic., mai-juin, p. C. 121.

Les **essais de locomotives** par la méthode Czeczott. (900 mots & fig.)

1936 **621 .392**

Revue universelle des transp. et des communic., juillet-août, p. C. 136.

La **soudure des rails.** (500 mots & fig.)

Traction nouvelle. (Paris.)

1936 **621 .43 (.44)**

Traction nouvelle, septembre-octobre, p. 146.

TOURNEUR (Ch.). — Les **autorails Bugatti.** (4 400 mots & fig.)

1936 **621 .43 (.44)**

Traction nouvelle, septembre-octobre. p. 156.

L'Etoile des **Michelines** de Lille. (1 400 mots & fig.)

1936 **621 .43 & 625 .25**

Traction nouvelle, septembre-octobre, p. 168.

FLEURY. — Derniers progrès réalisés dans le **freinage des automotrices.** (3 200 mots & fig.)

In German.

Die Lokomotive. (Wien.)

1936 **621 .132.3 (.72)**

Die Lokomotive, August, S. 137.

2 **D Heissdampf-Schnellzuglokomotiven** der Nationalbahn von Mexiko. (600 Wörter & Abb.)

1936 **621 .132.3 (.437)**

Die Lokomotive, September, S. 157.

1-D-2 **Drillings-Schnellzuglokomotive** Reihe 4861 der C. S. D., entworfen und gebaut von der Ceskomoravská-Kolben-Danek A. G., Prag. (2 000 Wörter & Abb.)

1936 **621 .335 (.439)**

Die Lokomotive, September, S. 160.

Die **elektrischen Lokomotiven** der kgl. ung. Staatsbahnen nach dem Kando'schen Phasenumformersystem. III. (6 400 Wörter.)

Die Reichsbahn. (Berlin.)

1936 **385 .517.6 (.43)**

Die Reichsbahn, Heft 38, 16. September, S. 757.

KRATZ. — Die Neuregelung des **bahnärztlichen Dienstes.** (3 000 Wörter.)

1936 **625 .1 (.43)**

Die Reichsbahn, Heft 38 A, 16. September, S. 769.

Ausbildung und Prüfung für den **höheren bautechnischen Verwaltungsdienst.** (800 Wörter & 5 Anlagen.)

Elektrische Bahnen. (Berlin.)

1936 **625 .2 & 669**

Elektrische Bahnen, Heft 8, August, S. 183.

MÜLLER (J.). — **Leichtmetallkonstruktionen.** (4 200 Wörter & Abb.)

1936 **621 .335 (.494)**

Elektrische Bahnen, Heft 8, August, S. 190.

STEINER. — Die ersten **Leichttriebwagen** der Schweizerischen Privatbahnen. (900 Wörter & Abb.)

1936 **625 .2 (.73) & 669 (.73)**

Elektrische Bahnen, Heft 8, August, S. 192.

SCHAEFER (H.). — Neue **Leichtzüge** einer New-Yorker U-Bahngesellschaft. (2 400 Wörter, 1 Tafel & Abb.)

1936 **625 .2 & 669**

Elektrische Bahnen, Heft 8, August, S. 199.

REIDEMEISTER (F.). — **Leichtmetallfahrzeuge.** (2 900 Wörter & Abb.)

Glasers Annalen. (Berlin.)

1936 **625 .2 (.43)**

Glasers Annalen, Heft 3, 1. August, S. 25; Heft 4, 15 August, S. 37.

DÄHNICK (E.). — Entwicklung der deutschen **Eisenbahnwagen.** (11 000 Wörter & Abb.) (Fortsetzung folgt.)

Organ für die Fortschritte des Eisenbahnwesens. (Berlin.)

1936 **621 .135.4**

Organ für die Fortschr. des Eisenbahnwesens, Heft 16, 15. August, S. 331.

HEUMANN. — Das **Einfahren von Lokomotiven in Gleisbögen.** (9 900 Wörter & Abb.)

1936 **621 .392 (43) & 625 .245 (.43)**

Organ für die Fortschr. des Eisenbahnwesens, Heft 17, 1. September, S. 349.

TASCHINGER (O.). — **Geschweisste Tiefladewagen.** (7 000 Wörter & Abb.)

1936 **621 .43 (.43)**

Organ für die Fortschr. des Eisenbahnwesens, Heft 17, 1. September, S. 358.

BREUER (M.). — Neue besonders leistungsfähige **Dieseltriebwagen** der Deutschen Reichsbahn. (1 300 Wörter & Abb.)

1936 **621 .392 (.436) & 665 .882 (.436)**

Organ für die Fortschr. des Eisenbahnwesens, Heft 17, 1. September, S. 360.

TITSCHER (J.). — Derzeitiger Stand und Anwendung der **Schweisstechnik** bei den Österreichischen Bundesbahnen. (5 000 Wörter & Abb.)

1936 **621 .133.7**

Organ für die Fortschr. des Eisenbahnwesens, Heft 17, 1. September, S. 367.

KNORR. — Leistungserhöhung der **Lokomotivspeisewasserkrane** eines Bahnhofs. (800 Wörter & Abb.)

1936 **625 .113**

Organ für die Fortschr. des Eisenbahnwesens, Heft 18, 15. September, S. 58.

SZMODITS (K.). — Besteht die Notwendigkeit eines **neuen Bogenabsteckverfahrens ?** (6 800 Wörter & Abb.)

1936 **625 .172**

Organ für die Fortschr. des Eisenbahnwesens, Heft 18, 15. September, S. 378.

HALTER (G.). — **Statische Untersuchung des Eisenbahngleises** auf zeichnerischem Wege. (1 900 Wörter & Abb.)

1936 **656 .222**

Organ für die Fortschr. des Eisenbahnwesens, Heft 18, 15. September, S. 381.

RAAB (F.). — Über eine exakte Methode der **Fahrzeitenermittlung.** (2 700 Wörter & Abb.)

Zeitschrift des Vereines Deutscher Ingenieure. (Berlin.)

1936 **621 .43**

Zeitschr. des Ver. deutsch. Ing., Nr. 34, 22. August, S. 1036.

NÄGEL (A.). — Gedanken zur **Schnelläufigkeit des Dieselmotors.** (4 500 Wörter & Abb.)

1936 **621 .392**

Zeitschr. des Ver. deutsch. Ing., Nr. 36, 5. September, S. 1111.

VIGENER (K.). — Verfahren zur Erzeugung hochwertiger **Schweissverbindungen.** (900 Wörter & Abb.)

1936 **621 .132.6 (.43)**

Zeitschr. des Ver. deutsch. Ing., Nr. 36, 5. September, S. 1113.

FLEMMING (F.). — **Steilstrecken-Tenderlokomotiven** der Deutschen Reichsbahn. (500 Wörter & Abb.)

1936 **656 .1 (.43)**

Zeitschr. des Ver. deutsch. Ing., Nr. 37, 12. September, S. 1117.

REISMANN (O.). — 1 000 Kilometer fertige **Kraftfahrbahnen.** (2 400 Wörter & Abb.)

1936 **691**

Zeitschr. des Ver. deutsch. Ing., Nr. 37, 12. September, S. 1129.

GRAF (O.). — Neuere **Untersuchungen mit Zement und Beton** zu grossen und wichtigen Bauwerken, insbesondere zu Betonstrassen, Brücken und Talsperren. (4 200 Wörter & Abb.)

1936 **669 .1**

Zeitsch. des Ver. deutsch. Ing., Nr. 38, 19. September, S. 1163.

RÄDEKER (W.) & SCHÖNE (E.). — **Technologische Eigenschaften grosser plattierter Bleche.** (1 800 Wörter, 4 Zahlentafeln & Abb.)

Zeitung des Vereins mitteleuropäischer Eisenbahnverwaltungen. (Berlin.)

1936 **656 .235 (.43)**

Zeitung des Ver. mitteleurop. Eisenbahnverw., Nr. 34, 20. August, S. 665.

SPIESS (W.). — Die **Gütertarifpolitik** der Reichsbahn. (3 100 Wörter.)

1936 **385 (.43)**

Zeitung des Ver. mitteleurop. Eisenbahnverw., Nr. 34, 20. August, S. 672.

BALLOF. — Die **Bahnen** im Deutschen Reich. (2 300 Wörter & 4 Tafeln.)

1936 **656 .235.6 (.43)**

Zeitung des Ver. mitteleurop. Eisenbahnverw., Nr. 35, 27. August, S. 695.

SEMAR. — Die **Verbandstarife** für den Personen-, Gepäck- und Expressgutverkehr mit den deutschen Privat- und Kleinbahnen und ihre Vereinfachung. (2 600 Wörter.)

1936 **385 .2 (.91.882)**
eitung des Ver. mitteleurop. Eisenbahnverw., Nr. 36, 3. September, S. 705.
PERTOT (V.). — **Wettbewerb** zwischen Bahn und chiffahrt in Jugoslawien. (4 100 Wörter.)

1936 **385 .113 (.436)**
eitung des Ver. mitteleurop. Eisenbahnverw., Nr. 36, 3. September, S. 714.
Geschäftsbericht der Österreichischen Bundesbahnen 935. (2 300 Wörter.)

1936 **656**
eitung des Ver. mitteleurop. Eisenbahnverw., Nr. 38, 17. September, S. 745.
COTTIER. — Die Erhaltung der volkswirtschaftlichen Mission der Eisenbahnen als Hauptziel der **Regelung des Wettbewerbs** zwischen Eisenbahn und Kraftwagen. (5 400 Wörter.)

In English.

Bulletin, American Railway Engineering Association. (Chicago, Ill.)

1936 **625 .143.3 (.73)**
Bulletin, American Ry. Engin. Association, June, p. 1.
MOORE (H. F.). — Second progress report on the nvestigation of **fissures in railroad rails.** (3 500 words & fig.)

1936 **385**
Bulletin, American Ry. Engin. Association, June, p. 17.
BUDD (R.). — **New opportunities of the railways.** (3 500 words.)

1936 **625 .1 (06 (.73)**
Bulletin, American Ry. Engin. Association, June, p. 23.
Address of President Robert H. Ford delivered at the Thirty-Seventh annual meeting (A. R. E. A.). (4 800 words.)

1936 **313 : 625 .142 (.73)**
Bulletin, American Ry. Engin. Association, June, p. 31.
Preliminary report of Committee III — **Ties. — Tie renewal statistics for 1935.** (Tables.)

1936 **625 .1 (06 (.73)**
Bulletin, American Ry. Engin. Association, June, p. 33.
Abstracts from discussion on **roadway.** (Railroad track. Economics of railway operation. Ballast. Rail. Iron and steel structures. Live load and impact. Records and accounts. Clearances, etc.) (6 800 words & fig.)

Engineer. (London.)

1936 **621 .83**
Engineer, No. 4207, August 28, p. 198; No. 4208, September 4, p. 222; No. 4209, September 11, p. 250; No. 4210, September 18, p. 278.
MERRITT (H. E.). — The art of **gear design.** (9 000 words & fig.)

1936 **55. (06 & 721 .1 (06**
Engineer, No. 4207, August 28, p. 199.
Soil mechanics and foundation engineering. (4 000 words.)

1936 **621 .13 (0**
Engineer, No. 4207, August 28, p. 209.
Locomotive power. (1 100 words.)

1936 **721 .9 (.06 (.42)**
Engineer, No. 4207, August 28, p. 213.
Final report of the **Steel Structures Research Committee.** (1 100 words.)

1936 **621 .39**
Engineer, No. 4207, August 28, p. 215.
An **ammeter** for stray currents. (500 words & fig.)

1936 **621 .13 (09**
Engineer, No. 4207, August 28, p. 223.
DENDY MARSHALL (C. F.). — **Links in the history of the locomotive.** William Chapman's engines. (2 200 words & fig.)

1936 **385. (091 (.51)**
Engineer, No. 4208, September 4, p. 225.
SMITH (M.). — **The Canton-Hankow Railway** and the development of China. (5 100 words & fig.)

1936 **621 .95 (.42)**
Engineer, No. 4208, September 4, p. 240.
An axle-box boring machine. (600 words & fig.)

1936 **669**
Engineer, No. 4208, September 4, p. 241.
HUDSON (F.). — **Mould and core-sand mixtures at elevated temperatures.** (The Institute of British Foundrymen. Thirty-third Annual Conference, Glasgow, June 9th to 12th, 1936.) (3 400 words, 5 tables & fig.)

1936 **621 .6 & 621 .43**
Engineer, No. 4208, September 4, p. 253.
KOVATS (A.). — Tests on **railcar coolers.** (4 400 words & fig.)

1936 **62**
Engineer, No. 4210, September 18, p. 279.
CHEVENARD (P.). — **On the function of science in works.** (7 500 words & 1 table.)

1936 **62. (06 (.42) & 621 .131.3 (.42)**
Engineer, No. 4210, September 18, p. 285.
The British Association. — Economic incentive of the engineer, paper by Dr. C. C. GARRARD. — Locomotive testing, paper by Mr. W. A. STANIER. — Holiday travel to Blackpool and its problems for the L.M.S., paper by Mr. Ashton DAVIES. (11 300 words.) (To be continued.)

1936 **533 & 656 .221**
Engineer, No. 4210, September 18, p. 298.
Early wind tunnel studies for the railroads. (700 words.)

1936 **62. (01 & 621 .82**
The Metallurgist, p. 147, Supplt. to the Engineer, August 28.
HAIGH (B. P.). — **Tin-base bearing metals.** (1 400 words.)

1936 **669 .1**
The Metallurgist, p. 149, Supplt. to the Engineer, August. 28.
The energy absorbed in the deformation of steel. (1 100 words & fig.)

1936 **621 .7**
The Metallurgist, p. 150, Supplt. to the Engineer, August 28.
A new method of **polishing metallic surfaces.** (1 600 words & fig.)

1936 **669 .1**
The Metallurgist, p. 152, Supplt. to the Engineer, August 28.
Iron-chromium-carbon alloys. (1 600 words & fig.)

1936 **621 .392 & 669**
The Metallurgist, p. 155, Supplt. to the Engineer, August 28.
Methods of **welding** aluminium and its alloys. (900 words & 2 tables.)

1936 **62. (01**
The Metallurgist, p. 157, Supplt. to the Engineer, August 28.
DEARDEN (W. H.). — **Grinding and polishing for micrography.** (2 500 words.)

1936 **669 .1**
The Metallurgist, p. 160, Supplt. to the Engineer, August 28.
Surface hardening of manganese steel. (600 words.)

Engineering. (London.)

1936 **621 .43 & 621 .8**
Engineering, No. 3686, September 4, p. 244.
HIGGS (G. R.). — **Diesel railcar transmission** systems. (3 000 words, 2 tables & fig.)

1936 **62. (01**
Engineering, No. 3686, September 4, p. 251.
Automatic Vicat-needle apparatus. (700 words & fig.)

1936 **721 .9 (06 (.42)**
Engineering, No. 3686, September 4, p. 255.
Steel structures research. (3 000 words.)

1936 **669**
Engineering, No. 3686, September 4, p. 256.
High-strength constructional metals. (2 000 words.)

1936 **621 .95 (.42)**
Engineering, No. 3686, September 4, p. 262.
Single-head **axlebox boring and facing machine.** (800 words.)

1936 **624**
Engineering, No. 3687, September 11, p. 269.
EVANS (R. H.) & THOMLINSON (J.). — Stress in the shear reinforcement of **reinforced-concrete beam.** (3 400 words, 3 tables & fig.)

1936 **621 .1**
Engineering, No. 3687, September 11, p. 273.
The Physical properties of **water and steam at hi temperature.** (Versuche der Masaryk-Akademie der A beit in Prag über die physikalischen Eigenschaften d Wassers und des Wasserdampfes.) (1 100 words fig.)

1936 **656 .212.6 (.4**
Engineering, No. 3687, September 11, p. 277.
Electrically-operated coal transporters at Port Ma ghera, Venice. (2 600 words & fig.)

1936 **621**
Engineering, No. 3687, September 11, p. 278.
The Wulfel fluid **change-speed gear.** (1 300 words fig.)

1936 **313 : 656 .1 (.42**
Engineering, No. 3687, September 11, p. 285.
Road traffic census, 1935. (1 100 words.)

1936 **621 .131.**
Engineering, No. 3688, September 18, p. 305.
STANIER (W. A.). — **The development and testin of locomotives.** — Paper read before Section G of th British Association at Blackpool, September 11, 193 (Abridged.) (3 800 words, 1 table & fig.)

1936 **62. (06 (.42) & 621 .131.3 (.42**
Engineering, No. 3688, September 18, p. 314.
The British Association meeting at Blackpool. — **Railway-locomotive development.** — Paper by Mr. W A. STANIER. (4 800 words.)

Engineering News-Record. (New York.)

1936 **624 .0 (.73**
Engineering News-Record, No. 7, August 13, p. 217.
Heat-treated bridge wire failures reproduced in tests — Investigation by Bureau of Standards of wire re moved from Mt. Hope bridge indicates inability o crystalline microstructure to resist fatigue fractur under fluctuating tensile loads as the cause of failure (3 600 words & fig.)

1936 **624. (0 (.73**
Engineering News-Record, No. 7, August 13, p. 221.
THUM (E. E.). — **Bridge wire tests** leave some questions unanswered. Critique of Bureau of Standards report. (2 800 words.)

1936 **614 .5**
Engineering News-Record, No. 7, August 13. p. 225.
GIES (R. W.). — **Mosquito control engineering.** — III. Control technique and organization. (2 800 words & fig.)

1936 **624 .62 (.73)**
Engineering News-Record, No. 7, August 13, p. 232.
STEINMAN (D. B.) & GRONQUIST (C. H.). — Designing the **longest fixed steel arch.** (3 800 words & fig.)

1936 **725 .33 (.73)**
Engineering News-Record, No. 7, August 13, p. 236.
SHEDD (M. C.). — **Steel water tank** on a tall tower moved 350 ft. to a new location. (900 words & fig.)

1936 **624. (0**
Engineering News-Record, No. 7, August 13, p. 249.
Heat-treated bridge wire. (700 words.)

1936 **624 .51 (.73)**
Engineering News-Record, No. 8, August 20, p. 255.
PURCELL (C. H.), ANDREW (Ch. E.) & WOODRUFF (G. B.). — **Bay bridge suspended structure.** (3 500 words & fig.)

1936 **614 .5**
Engineering News-Record, No. 8, August 20, p. 266.
CLARKE (J. L.). — **Mosquito control engineering.** — V. Inland control methods. (3 500 words & fig.)

1936 **55 & 721 .9**
Engineering News-Record, No. 8, August 20, p. 270.
Soil mechanics notes. — II. (4 200 words & fig.)

1936 **624 .51 (.73)**
Engineering News-Record, No. 9, August 27, p. 300
LEON (J. H.). — **Spinning cables** in the saddles. (3 000 words & fig.)

1936 **614 .5 (.73)**
Engineering News-Record, No. 9, August 27, p. 304.
VAN DERWERKER (R. J.). — **Mosquito control engineering.** — V. The salt marsh problem. (3 800 words & fig.)

Great Western Railway Magazine. (London.)

1936 **62. (01 & 624**
Great Western Ry. Magazine, September, p. 449.
An instrument for **measuring bridge-tremors** under passing loads. The autographic recording deflectometer. (1 000 words & fig.)

Journal of Applied Mechanics, A. S. M. E. (New York.)

1936 **624 .2**
Journal of Applied Mechanics, A. S. M. E., June, p. A-47.
MILES (A. J.). — **Stability of rectangular plates** elastically supported at the edges. (2 800 words & fig.)

1936 **624 .2**
Journal of Applied Mechanics, A. S. M. E., June, p. A-55.
MASON (H. L.). — **Impact on beams.** (3 900 words & fig.)

1936 **62. (01**
Journal of Applied Mechanics, A. S. M. E., June, p. A-63.
STURM (R. G.), DUMONT (C.) & HOWELL (F. M.). — A method of **analyzing creep data.** (3 500 words & fig.)

1936 **62. (01**
Journal of Applied Mechanics, A. S. M. E., June, p. A-67.
EVERETT (F. L.) & MAULBETSCH (J. L.). — Review of research in **strength of materials.** (4 500 words.)

Journal, Institution of Engineers, Australia. (Sydney, N. S. W.)

1936 **621 .165 & 621 .31**
Journal, Institut. of Engineers, Australia, July, p. 241.
GIBB (C. D.). — The influence of operating experience on the **design and construction of turbines and alternators.** (17 000 words & fig.)

1936 **614 .8 & 656 .1**
Journal, Institut. of Engineers, Australia, July, p. 261.
SHERRARD (H. M.). — **Highway safety and the engineer.** (5 800 words & fig.)

Journal, Western Society of Engineers. (Chicago.)

1936 **621 .31 (.73)**
Journal, Western Society of Engineers, June, p. 107.
Engineering economics in the National Power Picture. (9 papers and discussion presented under the auspices of the Western Society of Engineers at a session of the sixth Midwest Power Engineering Conference held at the Palmer House, Chicago, April 22, 1936.) (22 500 words, tables & fig.)

Mechanical Engineering. (New York.)

1936 **621 .116**
Mechanical Engineering, August, p. 479.
STUART (M. C.) & YARNALL (D. R.). — **Fluid flow through two orifices in series.** (4 300 words & fig.)

1936 **62. (01**
Mechanical Engineering, August, p. 485.
FROCHT (M. M.). — **Photoelastic studies in stress concentration, fillets, holes, and grooves in tension, compression, and bending.** (2 400 words & fig.)

1936 **621 (.73)**
Mechanical Engineering, September, p. 539.
CHRISTIE (A. G.). — **Development and performance of American power plants.** (15 000 words, tables & fig.)

1936 **621 .165 & 621 .18**
Mechanical Engineering, September, p. 562.
KRIEG (E. H.). — Superposition. — Factors involved in adding **high-pressure boilers and turbines** to existing plants. (5 800 words, 5 tables & fig.)

1936 **621 .18**
Mechanical Engineering, September, p. 573.
POWELL (J. A.). — **Design trends in 500-800 lb. steam plants.** (3 500 words & fig.)

1936 **621 .18 (.73) & 621 .31 (.73)**
Mechanical Engineering, September, p. 585.
BROWN (D. S.). — A superposed **power station.** (4 700 words & fig.)

Modern Transport. (London.)

1936 **621 .33 (.73)**
Modern Transport, No. 910, August 22, p. 2.
Electrification of U. S. A. railways. (1 000 words.)

1936 **621 .43 (.493 + .81)**
Modern Transport, No. 910, August 22, p. 3.
Oil-electric traction. Three-coach railcar in Brazil and Belgium. (1 100 words & fig.)

1936 **621 .43 (.73)**
Modern Transport, No. 910, August 22, p. 7.
Oil-electric locomotive for Illinois Central. (2 200 words & fig.)

1936 **625 .4 (.43)**
Modern Transport, No. 911, August 29, p. 3.
New **underground railway** for Berlin. Important section of Nordsüd-S-Bahn completed. 1 200 words & fig.)

1936 **625 .1 (.51)**
Modern Transport, No. 911, August 29, p. 5.
The Canton-Hankow railway. (1 800 words & fig.)

1936 **656 .1 (.42) & 656 .28 (.42)**
Modern Transport, No. 911, August 29, p. 7.
Causes of fatal road accidents. — Ministry of transport analysis. (2 000 words & 4 tables.)

1936 **656 .23 (.4)**
Modern Transport, No. 912, September 5, p. 3.
Double-deck suburban railway carriages. Comparison of modern types. (1 700 words & fig.)

1936 **621 .43 (.85)**
Modern Transport, No. 912, September 5, p. 5.
British-built **railcar for Peru.** — Articulated unit with detachable power bogie. (1 000 words & fig.)

1936 **621 .43 (.81)**
Modern Transport, No. 912, September 12, p. 5.
British-built **railcars** for Brazil. Diesel units with Cotal transmission. (1 200 words & fig.)

1936 **625 .235 & 698**
Modern Transport, No. 912, September 12, p. 6.
BASSETT (H. N.). — **Synthetic paints** and their advantages. — Suitability for modern requirements. (2 100 words & fig.)

Proceedings, American Society of Civil Engineers. (New York.)

1936 **624 .**
Proceed., Amer. Soc. Civil Engineers, August, p. 83
YOUNG (D.). — **Analysis of Vierendeel trusses** (5 500 words & fig.)

1936 **624 .**
Proceed., Amer. Soc. Civil Engineers, August, p. 86
SCHWALBE (W. L.). — **Simultaneous equation in mechanics solved by iteration.** (3 200 words & fig.)

Railway Age. (New York.)

1936 **624. (.73**
Railway Age, No. 5, August 1, p. 172.
Build **low-level bridge** to solve high-water problem (1 900 words & fig.)

1936 **621 .132.3 (.71**
Railway Age, No. 5, August 1, p. 175.
Streamline passenger locomotives for Canadian National. (1 300 words, fig. & 2 tables.)

1936 **656 .225 (.73) & 656 .261 (.73**
Railway Age, No. 5, August 1, p. 177.
Speed and efficiency in handling merchandise. Part I (1 500 words & fig.)

1936 **656 .23 (.73**
Railway Age, No. 5, August 1, p. 179.
WILSON (G. L.). — Multiple **car rates in Michigan** (3 700 words.)

1936 **625 .162 (.73) & 656 .259 (.73**
Railway Age, No. 5, August 1, p. 182.
Automatic crossing gates on the Louisville & Nashville. (2 700 words & fig.)

1936 **656 .257 (.73**
Railway Age, No. 7, August 15, p. 238.
Centralized traffic control on the Chesapeake & Ohio (1 900 words & fig.)

1936 **625 .23 (.43**
Railway Age, No. 7, August 15, p. 241.
German Road installs unique train. (1 200 words & fig.)

1936 **625 .13 (.73**
Railway Age, No. 7, August 15, p. 243.
Reinforced concrete lining used to advantage in old tunnel. (2 200 words & fig.)

1936 **625 .235 (.73**
Railway Age, No. 7, August 15, p. 245.
Metlvane **blind** for passenger cars. (600 words & fig.)

1936 **625 .142.3 (.73), 625 .18 (.73) & 625 .27 (.73)**

ailway Age, No. 7, August 15, p. 246.

Mc GUINNESS (F. J.). — **Sturdy buildings and eel equipment** for Delaware & Hudson stores. — ound construction aids supply work during depression. - Printing plant and machinery for metal ties feature erations. (1 800 words & fig.)

1936 **385 .1 (.73)**

ailway Age, No. 7, August 15, p. 249.

SWAINE (R. T.). — **Section 77 (Railroad Reorganiation Act)** full of imperfections. — Philosophy of ederal dictation of reorganization seen as threat to ntinued private operation. Part I. (4 800 words.)

1936 **625 .151 (.73)**

ailway Age, No. 7, August 15, p. 255.

Roller bearings for switches. (300 words & fig.)

1936 **624 (.73)**

ailway Age, No. 8, August 22, p. 271.

Apply rigid-frame design in subway at Ringgold, Tex. 1 500 words & fig.)

1936 **656 .254 (.73)**

ailway Age, No. 8, August 22, p. 273.

Telephones on the Union Pacific **streamliners.** 500 words & fig.)

1936 **656 .22 (.73)**

ailway Age, No. 8, August 22, p. 274.

Interstate Commerce Commission studies **light-weight assenger trains.** Statement of the Bureau of Statistics resents unit comparisons of weight, first cost and sts of operation. (5 600 words & 10 tables.)

1936 **385 .58 (.73)**

ailway Age, No. 8, August 22, p. 279.

Organization and discipline become outstanding problems. Superintendents consider the training of supervisors and the proper handling of men. (3 900 words.)

1936 **385 .1 (.73)**

ailway Age, No. 8, August 22, p. 282.

SWAINE (R. T.). — **Section 77 full of imperfections.** hould recapitalization be effected on present or prospective earning power? Act must be amended. Part II. 3 300 words.)

1936 **656 .261 (.73)**

ailway Age, No. 8, August 22, p. 285.

Avoiding junction delays to merchandises. Columbia erminals Company handles all L. C. L. interchange in t. Louis and East St. Louis (1 400 words & fig.)

1936 **656 .211.6 (.73)**

ailway Age, No. 8, August 22, p. 287.

Ten years of **train connection service.** (1 000 words fig.)

1936 **656 .211.5 (.73)**

ailway Age, No. 8, August 22, p. 289.

HERNLY (H. C.). — « Wild-cat » **ticket selling** uneconomic. (2 000 words & fig.)

1936 **656 .261 (.73)**

Railway Age, No. 8, August 22, p. 292.

Chicago Great Western begins **truck ferry service.** (700 words & fig.)

1936 **621 .132.8 (.73) & 621 .43 (.73)**

Railway Age, No. 9, August 29, p. 304.

Illinois Central gets powerful switcher. Largest **single-unit Diesel-electric locomotive** of this type will develop 2 000 horsepower. (3 900 words & fig.)

1936 **385 .113 (.73) & 625 .232 (.73)**

Railway Age, No. 9, August 29, p. 309.

A survey of **sleeping car services,** 1890-1935. (1 700 words.)

1936 **625 .142.2 (.73) & 625 .173 (.73)**

Railway Age, No. 9, August 29, p. 313.

Table tells story of **tie renewals** during the depression. (800 words & 1 table.)

1936 **621 .139 (.73) & 625 .27 (.73)**

Railway Age, No. 9, August 29, p. 317.

Neatness marks **supply work** of the Peoria & Pekin Union. (1 700 words & fig.)

Railway Engineering and Maintenance. (Chicago.)

1936 **625 .144.4 (.73)**

Railway Engineering & Maintenance, August, p. 470.

Ballasting a mile of track a day. (3 000 words & fig.)

1936 **621 .9 & 625 .13**

Railway Engineering & Maintenance, August, p. 475.

LOEFFLER (H. S.). — **Power tools aid trestle renewal.** (1 700 words & fig.)

1936 **625 .173 (.73) & 665 .882 (.73)**

Railway Engineering & Maintenance, August, p. 477.

Effective **track-welding** demands careful planning. (2 600 words & fig.)

1936 **625 .143.5 (.73)**

Railway Engineering & Maintenance, August, p. 481.

Treated gum shims salvage plate-cut bridge ties. (1 200 words & fig.)

1936 **625 .13 & 625 .143.5**

Railway Engineering & Maintenance, August, p. 483.

CAPP (F. W.). — **Fastening the rail to the bridge floor.** (1 500 words & fig.)

1936 **621 .144.4 (.73)**

Railway Engineering & Maintenance, September, p. 532.

Laying 282 miles of rail in 66 days. (3 400 words & fig.)

1936 **385 .517.7 (.73) & 625 .17 (.73)**

Railway Engineering & Maintenance, September, p. 536.

High class **camp cars** made from old passenger equipment. (1 700 words & fig.)

1936 **625 .144.4 (.73)**
Railway Engineering & Maintenance, September, p. 539.
Rail grinders. — What progress in their development? (2 400 words & fig.)

1936 **693**
Railway Engineering & Maintenance, September, p. 542.
Mixing and handling **concrete.** (2 000 words & fig.)

1936 **656 .211.5 (.73) & 721 .6 (.73)**
Railway Engineering & Maintenance, September, p. 545.
Better inter-track platforms and station tracks. (1 000 words & fig.)

Railway Gazette. (London.)

1936 **621 .134.2 (.42) & 621 .138.5 (.42)**
Railway Gazette, No. 8, August 21, p. 296.
COOK (K. J.). — Machining a **locomotive valve gear.** II. (2 000 words & fig.)

1936 **385 .1 (.460)**
Railway Gazette, No. 9, August 28, p. 337.
Spanish railways and **workers' control** (1 500 words & a map.)

1936 **656 .253 (.44)**
Railway Gazette, No. 9, August 28, p. 338.
Automatic interlocking on the Etat. (350 words & fig.)

1936 **656 .1 (.43)**
Railway Gazette, No. 9, August 28, p. 341.
Carting a modern locomotive. (150 words & fig.)

1936 **621 .334 (.42)**
Railway Gazette, No. 9, August 28, p. 342.
Electric railway yard vehicles. (800 words & fig.)

1936 **656 .211.7**
Railway Gazette, No. 9, August 28, p. 343.
A motorcar ferry (Dover-Ostend service), Belgian National Railways. (800 words & fig.)

1936 **621 .43 (.42) & 656 .261 (.42)**
Railway Gazette, No. 9, August 28, p. 345.
The Scammel **mechanical horse.** (600 words & fig.)

1936 **656 .225 (.73)**
Railway Gazette, No. 9, August 28, p. 346.
Containers in the U. S. A. (550 words & fig.)

1936 **656 .222.1 (.42)**
Railway Gazette, No. 10, September 4, p. 367.
British **main-line train services.** (1 500 words & 1 table.)

1936 **621 .392 (.73) & 625 .13 (.73)**
Railway Gazette, No. 10, September 4, p. 369.
Railway **bridge welding** in America. (800 words & fig.)

1936 **621 .135.2 (.44) & 621 .138.5 (.4**
Railway Gazette, No. 10, September 4, p. 371.
Differential gauge for measuring worn tyres. (6 words & fig.)

1936 **621 .132.8 (.5**
Railway Gazette, No. 10, September 4, p. 372.
Beyer-Garratt locomotives for Iran. (1 600 wor & fig.)

1936 **625 .234 (.9**
Railway Gazette, No. 10, September 4, p. 375.
Air-conditioned car for Trans-Australian Railwa (350 words & fig.)

1936 **694 (.4**
Railway Gazette, No. 10, September 4, p. 376.
Up-to-date joiners' shop, L. N. E. R. (300 wor & fig.)

1936 **659 (.7**
Railway Gazette, No. 10, September 4, p. 377.
The Rexall train (New York Central Railroad). (6 words & fig.)

1936 **656 .222.1 (.4**
Railway Gazette, No. 10, September 4, p. 381.
Another **British speed record.** (The Silver Jubil attains 113 m. p. h. down, and maintains an average 82.6 m. p. h. up, the same gradient.) (900 words & fig

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1936 **621 .132.8 (.4**
Railway Gazette, No. 11, September 11, p. 416.
German turbine locomotive practice. (1 900 wor & fig.)

1936 **621 .9 (.4**
Railway Gazette, No. 11, September 11, p. 419.
New machine for axlebox work. (400 words & fig.)

1936 **621 .43 (.44) & 656 .222 (.44**
Railway Gazette, No. 11, September 11, p. 420.
The Bugatti **railcars** and their services. (1 500 word & fig.)

1936 **62. (01 & 625 .143.**
Railway Gazette, No. 11, September 11, p. 422.
Sperry **rail detector,** Canadian Pacific Ry. (250 word & fig.)

1936 **621 .132.7 (.73**
Railway Gazette, No. 11, September 11, p. 423.
A new American **locomotive type.** (500 words & fig.

1936 **656 .211.5 (.42**
Railway Gazette, No. 11, September 11, p. 424.
Self-printing ticket machines. (Bell Punch Co., Ltd. (100 words & fig.)

1936 **621 .43 (.44**
Diesel Ry. Traction, p. 390, Supplt. to the Ry. Gazette September 4.
More **high-speed trains** in France. (820-b.h.p. triple car oil-electric trains, Ch. de fer du Nord.) (1 500 word & fig.)

1936 **621 .43 (.43)**
Diesel Ry. Traction, p. 393, Supplt. to the Ry. Gazette, September 4.
New German **railcar for local traffic** (150 b.h.p. M.A.N. engine). (400 words & fig.)

1936 **621 .43**
Diesel Ry. Traction, p. 394, Supplt. to the Ry. Gazette, September 4.
A two-stroke opposed-piston **railcar engine.** (800 words & fig.)

1936 **621 .43 (.4) & 656 .222.1 (.44)**
Diesel Ry. Traction, p. 396, Supplt. to the Ry. Gazette, September 4.
The streamlined Diesel train in Europe. (2 200 words & fig.)

1936 **621 .43 (.61)**
Diesel Ry. Traction, p. 400, Supplt. to the Ry. Gazette, September 4.
Diesel cars for North America. Well-known French standard model modified for subtropical passenger service. (900 words & fig.)

1936 **621 .43 (.43)**
Diesel Ry. Traction, p. 402, Supplt. to the Ry. Gazette, September 4.
Railcar operation in the Saar. (900 words & fig.)

1936 **621 .33 (.439)**
Electric Ry. Traction, p. 318, Supplt. to the Ry. Gazette, August 21.
LAJTHAY (E.). — **The operation of the Kando phase-converter system.** (2 000 words & fig.)

1936 **621 .331 (.945)**
Electric Ry. Traction, p. 323, Supplt. to the Ry. Gazette, August 21.
Switching cabins in Australia. (250 words & fig.)

1936 **621 .331 (.42)**
Electric Ry. Traction, p. 324, Supplt. to the Ry. Gazette, August 21.
Steel tank rectifiers in traction service. (1 600 words.)

Railway Signaling. (Chicago.)

1936 **656 .284 (.73)**
Railway Signaling, August, p. 405.
Union Pacific **streamliners** equipped with **cat signals.** (2 600 words & fig.)

1936 **625 .162 (.73) & 656 .259 (.73)**
Railway Signaling, August, p. 409.
Highway crossing signals on the Lehigh-New England. (1 500 words & fig.)

1936 **625 .162 (.73) & 656 .259 (.73)**
Railway Signaling, August, p. 411.
Semaphore type crossing gate developed on the Alton. (2 500 words & fig.)

1936 **656 .258 (.73)**
Railway Signaling, August, p. 414.
New York Central modernizes **electric interlocking.** (1 600 words & fig.)

1936 **625 .162 (.73) & 656 .259 (.73)**
Railway Signaling, August, p. 417.
Barrier crossing protection installed on the Long Island. (2 700 words & fig.)

1936 **625 .162 (.73) & 656 .259 (.73)**
Railway Signaling, August, p. 421.
Grand Trunk Western installs new **development in crossing protection.** (1 000 words & fig.)

The Locomotive. (London.)

1936 **621 .43 (.42)**
The Locomotive, August 15, p. 238.
Diesel engined railcar, Northern Counties Committee, L. M. S. R. (600 words & fig.)

1936 **625 .154 (.42)**
The Locomotive, August 15, p. 240.
Locomotive turning by power from the vacuum or air brake systems. (800 words & fig.)

1936 **625 .232 (.42)**
The Locomotive, August 15, p. 243.
New **composite sleeping cars,** L. M. S. R. (1 600 words & fig.)

1936 **621 .43 (.42)**
The Locomotive, August 15, p. 246.
Armstrong-Siddely **pneumatic-tyred railcar** demonstration, L. M. S. R. (1 600 words & fig.)

1936 **625 .154 (.42)**
The Locomotive, August 15, p. 248.
Non-balanced locomotive turntable, L. M. S. R. (350 words & fig.)

1936 **621 .138.5 (.44)**
The Locomotive, August 15, p. 248.
Plant for **repairs of superheater elements.** (350 words & fig.)

1936 **621 .138.5 (.42) & 621 .91 (.42)**
The Locomotive, August 15, p. 255.
The **Butler axlebox planer** specially designed for rapid production of bronze and steel axleboxes. (800 words & fig.)

1936 **621 .134.5**
The Locomotive, August 15, p. 257.
Lubrication of locomotive cylinders. (1 700 words.)

1936 **665 .882**
The Locomotive, August 15, p. 258.
Oxygen cutting in locomotive shops. (500 words & fig.)

The Railway Magazine. (London.)

1936 **656 .222.1 (.42)**

The Railway Magazine, September, p. 164.

The fastest trains in Great Britain. Summer time tables, 1936. (1 200 words & tables.)

1936 **656 .222.1 (.42)**

The Railway Magazine, September, p. 167.

ALLEN (C. J.). — **British locomotive practice and performance.** (4 400 words, tables & fig.)

Transactions, American Society of Mechanical Engineers. (New York.)

1936 **621 .115**

Transactions, Amer. Soc. of Mech. Engineers, July, p. 349.

HARDIE (P. H.) & COOPER (W. S.). — The accuracy of the cleanliness-factor measurement for **surface condensers.** (3 200 words & fig.)

1936 **669**

Transactions, Amer. Soc. of Mech. Engineers, July, p. 355.

BOETCHER (H. N.). — **Failure of metals** due to cavitation under experimental conditions. (3 900 words & fig.)

1936 **621 .6**

Transactions, Amer. Soc. of Mech. Engineers, July, p. 361.

FLETCHER (H. W.). — **Plunger lift for pumping deep wells.** (10 000 words & fig.)

1936 **62. (01 & 621 .9**

Transactions, Amer. Soc. of Mech. Engineers, July, p. 371.

BOSTON (O. W.), GILBERT (W. W.) & KRAUSS (C. E.). — **The influence of cutting fluids on tool life in turning steel.** (6 000 words & fig.)

1936 **621 .116**

Transactions, Amer. Soc. of Mech. Engineers, July, p. 389.

STRAUB (F. G.) & BRADBURY (T. A.). — **New laboratory data relative to embrittlement in steam boilers.** (1 400 words & 3 tables.)

1936 **621 .135.2 & 625 .14**

Transactions, Amer. Soc. of Mech. Engineers, July, p. 411.

Locomotive and car-journal lubrication. Published as paper RR-58-1, by E. S. PEARCE, in the January 1936 issue of the A. S. M. E. Transactions. (Discussion.) (8 300 words & fig.)

Transit Journal. (New York.)

1936 **388. (.**

Transit Journal, September, p. 297.

KNOWLTON (H. S.). — **What's happening to tran in Boston** (complete coordination of all local transpo ation in one system covering the entire metropoli area). (3 900 words & fig.)

1936 **385 .11 (.73) & 625 .62 (.**

Transit Journal, September, p. 305.

ROBERTS (E. A.). — **Life expectancy of street ca** (800 words & fig.)

In Spanish.

Revista de Obras Públicas. (Madrid.)

1936

Revista de Obras Públicas, nº 17, 1 de septiembre, p.

BESCOS (R. E.). — Algunas consideraciones so **hormigones.** (3 200 palabras & fig.)

1936

Revista de Obras Públicas, nº 18, 15 de sept., p.

CASADO (C. F.). — Colección de **puentes de alt** estricta. (4 200 palabras & fig.)

Rieles argentinos. (Buenos Aires.)

1936 **385 .1 (**

Rieles argentinos, junio, p. 147.

La **situación de los ferrocarriles** extranjeros y nuestro país. (2 900 palabras & fig.)

1936 **621 .43 (**

Rieles argentinos, junio, p. 154.

Modernización del material rodante de los Fe carriles del Estado argentino. (1 900 palabras &

Sociedad Geográfica de Lima. (Lima-Perú.)

1936 **656. (**

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SCHENK (G.). — Das **Metallspritzen.** Vergleich mit anderen Verfahren der Oberflächenveredelung. (4 200 Wörter & Abb.)

1936 **62. (01**
Zeitschr. des Ver. deutsch. Ing., Nr. 39, 26. September, S. 1199.

RINAGL (F.). — Die **Fliessgrenze** bei Biegebeanspruchung. (1 200 Wörter & Abb.)

1936 **625 .14 (01 & 625 .251**
Zeitschr. des Ver. deutsch. Ing., Nr. 41, 10. Oktober, S. 1256.

FÖPPL (L.). — Beanspruchung von **Schiene** und **Rad** beim Anfahren und Bremsen. (600 Wörter & Abb.)

1936 **621 .33 (.43)**
Zeitschr. des Ver. deutsch. Ing., Nr. 42, 17. Oktober, S. 1267.

TETZLAFF (H.). — Vom **elektrischen Zugbetrieb** der Deutschen Reichsbahn. (4 000 Wörter & Abb.)

1936 **621 .132.6**
Zeitschr. des Ver. deutsch. Ing., Nr. 42, 17. Oktober, S. 1280.

WOLFF (A.). — **Schwere Tenderlokomotive** für grosse Steigungen. (400 Wörter & Abb.)

1936 **621 .4 (09**
Zeitschr. des Ver. deutsch. Ing., Nr. 43, 24. Oktober, S. 1285.

LANGEN (A.). — Die Erfindung des **Verbrennungsmotors.** (4 000 Wörter & Abb.)

1936 **62. (01**
Zeitschr. des Ver. deutsch. Ing., Nr. 43, 24. Oktober, S. 1297.

Die Knickung von **Eisenbetonsäulen.** (1 000 Wörter & Abb.)

1936 **669 .1**
Zeitschr. des Ver. deutsch. Ing., Nr. 43, 24. Oktober, S. 1299.

LEYENSETTER (W.). — Einfluss der **Wärmebehandlung auf die Verarbeitungseigenschaften von Stählen.** (1 000 Wörter, 2 Tafeln & Abb.)

1936 **621 .43**
Zeitschr. des Ver. deutsch. Ing., Nr. 43, 24. Oktober, S. 1305.

BLAUM (E.). — Der Einspritzvorgang bei schnellaufenden **Dieselmotoren.** (900 Wörter & Abb.)

Zeitung des Vereins mitteleuropäischer Eisenbahnverwaltungen. (Berlin.)

1936 **656 .235 (.43)**
Zeitung des Ver. mitteleurop. Eisenbahnverw., Nr. 39, 24 September, S. 765.

SCHUBERT. — Organische Vereinfachungen im **Tarif- und Kontrollwesen des Güter- und Tiertarifs.** (6 200 Wörter.)

1936 **627 .82**
Zeitung des Ver. mitteleurop. Eisenbahnverw., Nr. 40, 1. Oktober, S. 785.

BONITZ. — Der **Rügendamm,** das neueste Glied des alten Verkehrsweges zwischen dem Kontinent und den nordischen Ländern. (11 000 Wörter & Abb.)

1936 **656 (.494)**
Zeitung des Ver. mitteleurop. Eisenbahnverw., Nr. 40 1. Oktober, S. 799.

Der Ersatz von Bahnlinien durch **Automobilbetriebe** bei den Schweizerischen Bundesbahnen. (1 200 Wörter.)

1936 **656. (.43)**
Zeitung des Ver. mitteleurop. Eisenbahnverw., Nr. 41 8. Oktober, S. 807.

TREIBE. — Das **Reisebüro** als Werber der Deutschen Reichsbahn. (2 900 Wörter.)

1936 **385 .113 (.44)**
Zeitung des Ver. mitteleurop. Eisenbahnverw., Nr. 43 22. Oktober. S. 851.

WERNEKKE. — Die **französischen Eisenbahnen** im Jahre 1935. 8 200 Wörter.)

1936 **621 .132.8 & 656 .222.**
Zeitung des Ver mitteleurop. Eisenbahnverw., Nr. 44 29. Oktober, S. 871.

FLEMMING (F.). — Schnellverkehr mit **Dampfzügen** (8 000 Wörter & Abb.)

In English.

Engineer. (London.)

1936 **621 .8**
Engineer, No. 4211, September 25, p. 306.

MERRITT (H. E.). — The art of **gear design.** — No. XI. (3 000 words & fig.)

1936 **656 .211.7 (.42) & 699 (.42**
Engineer, No. 4211, September 25, p. 312.

The Denny-Brown **ship stabiliser.** (2 900 words fig.)

1936 **621 .43 (.85**
Engineer, No. 4211, September 25, p. 316.

A new **railcar** for Peru. (1 200 words & fig.)

1936 **621 .131**
Engineer, No. 4211, September 25, p. 319.

Locomotive tests. (1 400 words.)

1936 **621 .43 (.82)**
Engineer, No. 4211, September 25, p. 328.
Railcar operation in the Argentine. (1 300 words & 2 tables.)

1936 **621 .8**
Engineer, No. 4212, October 2, p. 334; No. 4213, October 9, p. 366; No. 4214, October 16, p. 398.
MERITT (H. E.). — The art of **gear design.** (11 000 words & fig.)

1936 **669.** (06 (.42)
Engineer, No. 4212, October 2, p. 335.
The Institute of Metals. No. II. — **Metals of the platinum group.** — Study of the forgeability of various light and ultra-light alloys. — The creep of tin and tin alloys. — Veining and sub-boundary structures in metals. (2 300 words.)

1936 **621.** (06 (∞)
Engineer, No. 4212, October 2, p. 341.
The Third Power Conference. — (3 200 words.)

1936 **62.** (06 (.42)
Engineer, No. 4212, October 2 p. 357.
The British Association. No. III. — **Safety on roads. — High-speed C. I. engines. — Defence against hostile aircraft.** (7 700 words.)

1936 **669.** (06 (.42)
Engineer, No. 4212, October 2, p. 359.
The Iron and Steel Institute. No. 1, Technical meetings. — **Furnaces in German steel works,** by Dr.-Ing. Friedrich WESEMAN. — **The determination of the gases in steel,** by the hot extraction method. (3 400 words.)

1936 **669.** (06 (.42)
Engineer, No. 4213, October 9, p. 373.
The Iron and Steel Institute. No. II. — **Visists and excursions** (2 700 words & fig.) (To be continued.)

1936 **656 .211.7 (.42 + .44)**
Engineer, No. 4213, October 9, p. 377; No. 4214, October 16, p. 404.
The Dover **train ferry.** (4 200 words & fig.)

1936 **621 .13 (0**
Engineer, No. 4213, October 9, p. 382.
STANIER (W. A.). — Recent development of **locomotive design.** (3 200 words, 2 tables & fig.)

1936 **669.** (06 (.42)
Engineer, No. 4214, October 19, p. 388.
The Iron and Steel Institute. — No. II. Technical meetings. — **Damping capacity of metals. — Grain size in steel. — Rolling mill problems.** (4 800 words.)

1936 **621 .86**
Engineer, No. 4214, October 19, p. 390.
A heavy duty **aerial ropeway.** (900 words & fig.)

1936 **621.** (06 (∞)
Engineer, No. 4214, October 16, p. 413.
The Third World Power conference. No. III. — **Organisation of private electric and gas utilities. — Natural and manufactured gas. Conservation of coal resources.** (4 900 words & fig.)

Engineering. (London.)

1936 **656 .211.7 (.42) & 699 (.42)**
Engineering, No. 3689, September 25, p. 334.
The Denny-Brown **ship stabiliser.** (2 600 words & fig.)

1936 **62.** (06 (.42)
Engineering, No. 3689, September 25, p. 341.
Traffic problems on the London Midland & Scottish Ry. (5 600 words.)

1936 **669.** (06 (.42)
Engineering, No. 3689, September 25, p. 344.
The Institute of Metals : Paris meeting. Proceedings. Conductivity of high-purity aluminium. — Properties of alloys and industrial conditions. — Properties of aluminium alloys after prolonged heating. — The production of aluminium reflectors. (5 200 words & 1 table.)

1936 **537 .7**
Engineering, No. 3689, September 25, p. 347; No. 3690, October 2, p. 376.
LANCHESTER (F. W.). — **Electrical dimensions and units.** (5 600 words & fig.)

1936 **669.** (06 (.42)
Engineering, No. 3690, October 2, p. 356.
The Institute of Metals : Paris Meeting. Proceedings. — Forgeability of light aloys. — Creep of tin and tin alloys. — Veining and sub-boundary structures in metals. (4 000 words & fig.)

1936 **624.** (0
Engineering. No. 3690, October 2, p. 367.
The weights of steel bridges. (1 400 words.)

1936 **669.** (06 (.42)
Engineering, No. 3690, October 2, p. 369.
The Iron and Steel Institute; Düsseldorf meeting. — German iron and steel production during the last fifteen years. — Firing of open-hearth furnaces. — Influence of coke quality on blast-furnace operations. (1 900 words.) (To be continued.)

1936 **62.** (06 (.42)
Engineering, No. 3690, October 2, p. 371.
The British Association meeting at Blackpool. Section G. — Engineering. — Science and road safety. — Headlight glare and illumination in fog. (4 000 words.)

1936 **656 .211.7 (.42 + .44)**
Engineering, No. 3691, October 9, p. 390.
The Dover dock for the cross-Channel **train ferry service.** (2 600 words & fig.)

1936 **662**

Engineering, No. 3691, October 9, p. 395.

Coal breakage. (2 200 words.)

1936 **669 .1 (06 (.42)**

Engineering, No. 3691, October 9, p. 397.

The Iron and Steel Institute : Düsseldorf meeting. — **Damping capacity of metals.** (5 000 words.)

1936 **62. (06 (.42)**

Engineering, No. 3691, October 9, p. 399.

The British Association meeting at Blackpool. — Section Engineering. — **High-speed diesel engines.** — **Demonstration of anti-dazzle devices.** (2 200 words.)

1936 **385 .111 (.82) & 621 .43 (.82)**

Engineering, No. 3691, October 9, p. 400.

Railcar operation in the Argentine. (1 600 words, 4 tables & fig.)

1936 **62. (06 (.42)**

Engineering, No. 3692, October 16, p. 408.

The British Association meeting at Blackpool. — Section G. Engineering. — **Radiation from combustion gases.** — **Transverse elasticity of building materials.** (2 500 words & fig.)

1936 **625 .234**

Engineering, No. 3692, October 16, p. 410.

Air conditioning of trains. (900 words & fig.)

1936 **621 .89**

Engineering, No. 3692, October 16, p. 420.

Journal lubrication. (2 000 words.)

1936 **621 .9 (.54)**

Engineering, No. 3692, October 16, p. 431.

Hydraulic locomotive wheel press. (700 words.)

1936 **669 .1 (06 (.42)**

Engineering, No. 3692, October 16, p. 433.

SWINDEN (T.). — **Controlled grain size in steel.** (3 300 words & tables.)

Engineering News-Record. (New York.)

1936 **624 .62 (.73)**

Engineering News-Record, No. 10, September 3, p. 328.

Continuity and determinacy combined in new bridge. (2 300 words & fig.)

1936 **614 .5 (.73)**

Engineering News-Record, No. 10, September 3, p. 341; No. 11, September 10, p. 372.

Mosquito control engineering — VI. Effective malaria control. (4 700 words & fig.)

1936 **624 .32 (.73)**

Engineering News-Record, No. 11, September 10, p. 362.

PARCEL (J. I.). — Long **continuous truss bridge** spans Mississippi River. (2 500 words & fig.)

1936 **614 .5 (.73)**

Engineering News-Record, No. 11, September 10, p. 374.

CORKRAN (W. S.). — **Mosquito abatement** in Delaware. (2 600 words & fig.)

1936 **614 .5 (.73)**

Engineering News-Record, No. 12, September 17, p. 404.

LE PRINCE (J. A.). — **Mosquito control engineering.** VIII. (Concluded.) — Malaria and the Mississippi Valley. (1 700 words.)

1936 **624 .8 (.73)**

Engineering News-Record, No. 12, September 17, p. 408.

LAWSON (H.). — **Double track bascule span** employs welded design. (900 words & fig.)

1936 **624**

Engineering News-Record No. 14, October 1, p. 471.

EVANS (L. T.). — **Vierendeel girder bridge** introduced in America. (700 words & fig.)

Great Western Railway Magazine. (London.)

1936 **625 .235 (.42)**

Great Western Ry. Magazine, October, p. 478.

The construction of **steel-panelled coaches.** (1 200 words & fig.)

Journal of Applied Mechanics, A. S. M. E. (New York.)

1936 **62. (01 & 625 .212**

Journal of Applied Mechanics, A. S. M. E., September p. A-91.

HORGER (O. J.) & MAULBETSCH (J. L.). — Increasing the **fatigue strength of press-fitted axle assemblies** by surface rolling. (5 200 words & fig.)

1936 **62. (01**

Journal of Applied Mechanics, A. S. M. E., September p. A-98.

FROCHT (M. M.). — **The behavior of a brittle material at failure.** (1 700 words & fig.)

1936 **62. (01 & 669**

Journal of Applied Mechanics, A. S. M. E., September p. A-104.

NADAL (A.). — A review of recent **research work in plasticity.** (2 600 words.)

1936 **62. (01 & 621 .8**

Journal of Applied Mechanics, A. S. M. E., September p. A-111.

Journal bearing performance, by R. BAUDRY & L. M. TICHVINSKY. (Discussion.) (Paper published in the December 1935 issue of the Journal of Applied Mechanicas, Trans. A. S. M. E., vol. 57, 1935, p. A-121.) (3 000 words & fig.)

Journal, Institution of Civil Engineers. (London.)

1936 **624 .51 (.71)**

Journal, Institution of Civil Engineers, No. 8, October, p. 357.

BANKS (S. R.). — The **superstructure** of the Island of Orleans **suspension bridge**, Quebec, Canada. (47 000 words & fig.)

1936 **625 .13 (.42)**

Journal, Institution of Civil Engineers, No. 8, October, p. 472.

BUCKTON (E. J.) & FEREDAY (H. J.). — **The demolition of Waterloo bridge.** (20 000 words & fig.)

1936 **385. (09.1 (.66)**

Journal, Institution of Civil Engineers, No. 8, October, p. 613.

BINDLEY (H. D.). — **Sudan Railways**, 1925-1935. (2 700 words & fig.)

1936 **625 .13 (.44)**

Journal, Institution of Civil Engineers, No. 8, October, p. 649.

ANDERSON (D.). — The construction of the Mersey **tunnel.** (5 300 words & fig.)

Journal, Institution of Engineers, Australia. (Sydney, N. S. W.)

1936 **62. (01 & 621 .392**

Journal, Institution of Engineers, Australia, August, p. 286.

ISAACS (D. V.). — **The distribution of stresses in fillet welds.** (5 300 words, 6 tables & fig.)

Mechanical Engineering. (New York.)

1936 **698**

Mechanical Engineering, October, p. 621.

MOORE (R. J.). — **Synthetic resins in varnishes for wood protection.** (3 600 words & 6 tables.)

1936 **532 & 533**

Mechanical Engineering, October, p. 625.

BAKHMETEFF (B. A.). — The Reynolds number. A simplified explanation of the significance of this important quantity and examples of its use in aerodynamics and hydraulics. (3 400 words & fig.)

1936 **621 .43**

Mechanical Engineering, October, p. 635.

HECHLER (F. G.). — **Diesel engineering instruction.** (3 700 words.)

1936 **621 .7 & 669**

Mechanical Engineering, October, p. 639.

KUNKLER (L. E.). — **Spraying of molten metal.** (2 500 words.)

1936 **536**

Mechanical Engineering, October, p. 643.

JAKOB (M.). — **Heat transfer in evaporation and condensation** — I. (30 000 words & fig.)

Modern Transport. (London.)

1936 **621 .131.3**

Modern Transport, No. 914, September 19, p. 3.

STANIER (W. A.) — Development and testing of locomotives. — **The dynamometer car and its uses.** (2 500 words & fig.)

1936 **625 .232 (.42)**

Modern Transport, No. 914, September 19, p. 5.

Buffet cars for L. M. S. R. — New ideas in internal fittings. (1 200 words & fig.)

1936 **621 .336 (.42)**

Modern Transport, No. 914, September 19, p. 6.

Electrical conversion on Mersey Railway. — Position of conductor rail altered. (1 700 words & fig.)

1936 **656 .222 (.42) & 656 .23 (.42)**

Modern Transport, No. 914, September 19, p. 7.

DAVIES (A.). — **Passenger traffic problems** on the L. M. S. R. — Holiday travel to Blackpool (3 000 words & fig.)

1936 **625 .244 & 656**

Modern Transport, No. 914, September 19, p. 9.

HERBERT (T. M.). — **The transport of food. — Refrigerated vans and containers.** (1 600 words.)

1936 **347 .763 (.42) & 656 (.42)**

Modern Transport, No. 914, September 19, p. 12

Road and rail traffic comparisons. — Proceedings at Westminster. — Strong opposition to Bouts-Tillottson application for licence renewals. (2 200 words.)

1936 **621 .1, 621 .43 & 656 .1**

Modern Transport, N° 915, September 26, p. 2.

GAUNT (W. H.). — **Petrol, oil and steam road vehicles.** — Experience of an operator. (2 600 words & fig.)

1936 **621 .43 (.82)**

Modern Transport, No. 915, September 26, p. 4.

Oil electric railcars in the Argentina. Results on Buenos Aires Western Railway. (1 800 words & fig.)

1936 **621 .132.3 (.42) & 621 .132.5 (.42)**

Modern Transport, No. 915, September 26, p. 5.

Rebuilt mixed traffic locomotives. Great Western Railway « Grange » class. (1 000 words, 1 table & fig.)

1936 **656 .1 (.43) & 656 .261 (.43)**

Modern Transport, No. 915, September 26, p. 9.

Road-rail transport in Germany. A trailer for railway goods wagons. (900 words & fig.)

1936 **656 .1 (.42)**

Modern Transport, No. 916, October 3, p. 3.

Road haulage wages. (1 800 words.)

1936 **621 .43 (.489)**

Modern Transport, No. 916, October 3, p. 4.

Diesel-electric traction in Denmark. New Frichs heavy-duty locomotives. (1 100 words & fig.)

1936 **621 .13 (0**
Modern Transport, No. 916, October 3, p. 5.
STANIER (W. A.). — **Development in steam locomotive design.** — Securing greater power and efficiency. (2 800 words & 1 table.)

1936 **621 .392 & 625 .143**
Modern Transport, No. 916, October 3, p. 6.
STRAUSS (F.). — **Welding of steel rails.** (1 700 words.)

1936 **621 .43 (.44)**
Modern Transport, No. 916, October 3, p. 7.
Petrol-engined railcars in France. — Three-coach unit with Cotal transmission. (1 000 words & fig.)

1936 **656. (09**
Modern Transport, No. 916, October 3, p. 9.
Looking backwards from 1970. — A century of **progress in transport.** (2 400 words.)

1936 **656 .211.7 (.42 + .44)**
Modern Transport, No. 917, October 10, p. 3.
First **passenger train ferry** to the Continent. (3 000 words & fig.)

1936 **625 .4 (.42) & 625 .61 (.42)**
Modern Transport, No. 917, October 10, p. 6.
Ramsgate's **underground railway.** — An interesting 2-ft.-gauge system. (1 300 words & fig.)

1936 **385 .1 (.42)**
Modern Transport, No. 917, October 10, p. 7.
WOOD (W. V.). — **Financial practice of British Railways.** (2 300 words & 1 graph.)

1936 **656 .211.7 (.42 + .44)**
Modern Transport, No. 918, October 17, p. 3.
By **sleeping-car train** to Paris. (1 300 words & fig.)

1936 **621 .132.6 (.62)**
Modern Transport, No. 918, October 17, p. 4.
British-built **locomotives** for Egypt. (500 words & fig.)

1936 **385 .22 (.42)**
Modern Transport, No. 918, October 17, p. 5.
READ (Sir Alfred). — **Coastal shipping and transport co-ordination.** (2 300 words.)

1936 **656 .25 (.41)**
Modern Transport, No. 918, October 17, p. 7.
GUTHRIE (H. J.). — **Railway signalling** in Irish Free State. (2 000 words & fig.)

1936 **621 .132.7 & 621 .43**
Modern Transport, No. 918, October 17, p. 9.
Operation of shunting services. — Replacing horses and locomotives. (2 300 words & fig.)

1936 **656 .1 (.42) & 656 .2 (.42)**
Modern Transport, No. 918, October 17, p. 11.
Road and rail traffic comparisons. (2 700 words.)

Proceedings, American Society of Civil Engineers. (New York.)

1936 **624 .2**
Proceed., Amer. Soc. of Civil Engineers, September, p. 995.
GRINTER (L. E.). — **Analysis of continuous frames by balancing angle changes.** (5 400 words & fig.) p. 1025.

1936 **627 .82**
Proceed., Amer. Soc. of Civil Engineers, September, p. 1025.
LEE (Ch. H.). — **Selection of materials for rolled-fill earth dams.** (6 400 words, tables & fig.)

1936 **624 .63**
Proceed., Amer. Soc. of Civil Engineers, September, p. 1043.
NEWMARK (N. M.). — Interaction between rib and superstructure in **concrete arch bridges.** (7 900 words & fig.)

Railway Age. (New York.)

1936 **385. (.73) & 659. (.73)**
Railway Age, No. 10, September 5, p. 336.
A. A. R. public relations program now under full steam. (4 500 words & fig.)

1936 **625 .232 (.73)**
Railway Age, No. 10, September 5, p. 340.
Pullman tries **two-unit articulated sleeper observation car.** (1 200 words & fig.)

1936 **621 .139 (.73) & 625 .27 (.73)**
Railway Age, No. 10, September 5, p. 343.
Visible records for **storekeeping.** (1 400 words & fig.)

1936 **625 .111 (.73)**
Railway Age, No. 10, September 5, p. 345.
53 miles of railway relocated in Ohio flood-control project. (3 500 words & fig.)

1936 **385 .1 (.73)**
Railway Age, No. 11, September 12, p 362.
A four years' discussion of business and business problems. (5 400 words.)

1936 **625 .232 (.73)**
Railway Age, No. 11, September 12, p. 367.
Pennsylvania experimenting with **coach modernizing schemes.** (1 400 words & fig.)

1936 **625 .162 (.73) & 656 .259 (.73)**
Railway Age, No. 11, September 12, p. 370.
Real progress being made in federal **grade crossing program.** (2 400 words, 1 table & fig.)

1936 **625 .143 (0 (.73) & 621 .335 (.73)**
Railway Age, No. 11, September 12, p. 374.
Track tests of electric locomotives. (4 600 words & fig.)

1936 **385.** (072 & **656** .2
Railway Age, No. 11, September 12, p. 381.
DUCAN (C. S.). — **Economic research and transportation.** (3 300 words.)

1936 **625** .142.2 (.73) & **625** .173 (.73)
Railway Age, No. 12, September 19, p. 402.
Thirty-five years of **continuous crosstie research.** (6 500 words & fig.)

1936 **621** .43 (.73)
Railway Age, No. 12, September 19, p. 409.
Seaboard Air Line installs **diesel-powered railcar.** (900 words & fig.)

1936 **621** .139 (.73) & **621** .33 (.73)
Railway Age, No. 12, September 19, p. 410.
DASCHBACK (J. L.). — Lessons from **storekeeping** for railway electrification. (1 500 words & fig.)

1936 **621** .335 & **625** .143 (0
Railway Age, No. 12, September 19, p. 412.
Track tests of **electric locomotives.** (3 000 words & fig.)

1936 **621** .132.3 (.73) & **621** .135.2 (.73)
Railway Age, No. 13, September 26, p. 435.
Norfolk & Western locomotives equipped with **roller bearings.** (1 300 words & fig.)

1936 **625** .1 (06 (.73)
Railway Age, No. 13, September 26, p. 438; No. 14, October 3, p. 483.
Roadmasters held profitable **Convention** at Chicago, September 15-17, 1936. (2 800 words.)

1936 **656** .2 (0
Railway Age, No. 13, September 26, p. 445.
Speeding up terminal operations. (2 800 words.)

1936 **621** .13 (06 (.73)
Railway Age, No. 13, September 26, p. 447.
Fuel and Traveling Engineers' Association unite. (2 500 words.)

1936 **656** .211.6 (.73)
Railway Age, No. 13, September 26, p. 449.
Collection and delivery of passengers. (1 800 words & fig.)

1936 **621** .43 (.73) & **656** .1 (.73)
Railway Age, No. 13, September 26, p. 453.
Auto-railer in revenue service. (1 300 words & fig.)

1936 **656** .261 (.73)
Railway Age, No. 13, September 26, p. 455.
Freight handling device tested. (650 words & fig.)

1936 **625** .162 (.73)
Railway Age, No. 14, October 3, p. 470.
Chicago & North Western installs **automatic gates.** (2 200 words & fig.)

1936 **621** .132.3 (.73) & **625** .23 (.73)
Railway Age, No. 14, October 3, p. 479.
Canadian Pacific Railways buys **streamline steam locomotives.** (2 000 words, 1 table & fig.)

1936 **313 : 656** .28 (.73)
Railway Age, No. 14, October 3, p. 486.
Steam railway accident statistics 1922-1935. (1 500 words.)

Railway Engineering and Maintenance. (Chicago.)

1936 **625** .172 (.73) & **698** (.73)
Railway Engineering & Maintenance, October, p. 602.
How far behind is painting ? (7 900 words & fig.)

1936 **625** .1 (06 (.73)
Railway Engineering & Maintenance, October, p. 611.
Roadmasters hold fifty-first convention, September 15-17, 1936. Report on the use of work equipment. Report on selection and training of foremen. Report on preparing track for high speed operation. Report on the inspection of rail. Report on rail lubrication. — Addresses. Papers. Track supply exhibit. (45 000 words & fig.)

Railway Gazette. (London.)

1936 **656** .222 (.42)
Railway Gazette, No. 12, September 18, p. 440.
The « How » of Blackpool. — **Holiday travel** to Blackpool (L. M. S. R.). (1 000 words & fig.)

1936 **621** .131.3
Railway Gazette, No. 12, September 18, p. 441.
Mr. Stanier, Chief Mechanical Engineer, L. M. S. R., on **testing of locomotives.** (1 000 words.)

1936 **656** .211.7 (.42) & **699** (.42)
Railway Gazette, No. 13, September 25, p. 489.
New anti-rolling device for ships. (800 words & fig.)

1936 **621** .132.3 (.42) & **621** .132.5 (.42)
Railway Gazette, No. 13, September 25, p. 490.
New mixed-traffic locomotives, G. W. R. (300 words & fig.)

1936 **621** .138.5 (.42) & **662.** (.42)
Railway Gazette, No. 13, September 25, p. 492.
Pulverised fuel plant at Crewe locomotive works, L. M. S. R. (700 words & fig.)

1936 **656** .261 (.42)
Railway Gazette, No. 13, September 25, p. 495.
Collecting fruit and roots. (700 words & fig.)

1936 **656** .211.6 (.73)
Railway Gazette, No. 13, September 25, p. 499.
Important **railway terminal facilities** provided by road. (700 words & fig.)

1936 **625 .111 & 625 .15 (.42)**
Railway Gazette, No. 14, October 2, p. 521.
BOND (W. M.). — **High speed junctions.** — I. (3 200 words & fig.) (To be continued.)

1936 **656 .211.7 (.42) & 656 .213 (.42)**
Railway Gazette, No. 14, October 2, p. 525.
Dover train ferry dock, Southern Railway. (2 600 words & fig.)

1936 **625 .215 (.54)**
Railway Gazette, No. 14, October 2, p. 528.
Sheffield double frame welded 5 ft. 6 in. gauge **passenger bogies** for the Bengal-Nagpur Railway. (600 words & fig.)

1936 **621 .132.6 (.68)**
Railway Gazette, No. 14, October 2, p. 529.
Tank locomotive for South Africa. (350 words & fig.)

1936 **62. (01 (.73) & 625 .143.3 (.73)**
Railway Gazette, No. 14, October 2, p. 531.
Detecting rail defects at permanent way depots. (1 000 words & fig.)

1936 **621 .13 (0**
Railway Gazette, No. 14, October 2, p. 536.
Recent development of **locomotive design.** (Presidential address by Mr. W. A. STANIER to the Institution of Locomotive Engineers. (3 000 words.)

1936 **656 .222.1 (.73)**
Railway Gazette, No. 15, October 9, p. 573.
102 miles an hour aboard the Hiawatha. (900 words.)

1936 **621 .134.1 (.437)**
Railway Gazette, No. 15, October 9, p. 574.
The Skoda **locomotive booster.** (1 300 words & fig.)

1936 **625 .111 & 625 .15 (.42)**
Railway Gazette, No. 15, October 2, p. 577.
BOND (W. M.). **High speed junctions** — II. (3 500 words & fig.)

1936 **621 .138 (.42) & 621 .9 (.42)**
Railway Gazette, No. 15, October 9, p. 581.
A locomotive machine shop innovation. (1 000 words & fig.)

1936 **621 .132.6 (.8)**
Railway Gazette, No. 15, October 9, p. 583.
New **tank locomotives** for Brazil. (450 words & fig.)

1936 **385 .1 (.42)**
Railway Gazette. No. 15, October 9, p. 589.
Some aspects of **railway finance.** (1 800 words & fig.)

1936 **656 .222 (.42)**
Railway Gazette, No. 15, October 9, p. 590.
The longest **British non-stop runs.** (800 words & 2 tables.)

1936 **656 .25 (.41)**
Railway Gazette, No. 16, October 16, p. 611.
GUTHRIE (H. J.). — **Signalling developments** in the Irish Free State. (4 800 words & fig.)

1936 **656 .211.7 (.42 + .44)**
Railway Gazette, No. 16, October 16, p. 619.
New Channel **ferry service.** (1 900 words & fig.)

1936 **621 .132.6 (.62)**
Railway Gazette, No. 16, October 16, p. 627.
New **2-4-2 type tank locomotives** for the Egyptian State Railways. (450 words & fig.)

1936 **621 .43 (.42) & 656 .222.5 (.42)**
Diesel Ry. Traction, p. 548, Supplt. to the Ry. Gazette, October 2.
The Great Western Diesel **railcar services.** (2 200 words & fig.)

1936 **621 .43 (.43) & 621 .8 (.43)**
Diesel Ry. Traction, p. 553. Supplt. to the Ry. Gazette, October 2.
MIALL (S.). — Transmissions for **Diesel locomotives and railcars.** (1 300 words & fig.)

1936 **621 .43**
Diesel Ry. Traction, p. 556, Supplt. to the Ry. Gazette, October 2.
The development of the **high-speed oil engine.** (1 300 words.)

1936 **621 .43 (.460)**
Diesel Ry. Traction, p. 557. Supplt. to the Ry. Gazette, October 2.
Spanish locomotives for marshalling service. (600 words & fig.)

1936 **621 .43 (.493)**
Diesel Ry. Traction, p. 558, Suppl. to the Ry. Gazette, October 2.
Belgian streamlined train. (1 000 words & fig.)

1936 **621 .43**
Diesel Ry. Traction, p. 560, Supplt. to the Ry. Gazette, October 2.
Fuel combustion in high-speed oil engines. (1 400 words.)

1936 **621 .336 (.436)**
Electry Ry. Traction, p. 640, Supplt. to Ry. Gazette, October 16.
KAAN (E. R.). — **Standard overhead equipment** Austrian Federal Railways. (2 200 words & fig.)

Railway Magazine. (London.)

1936 **656 .222.1 (.42)**
Railway Magazine, October, p. 237.
British express trains in the Summer. (2 800 words & fig.)

1936 **656 .222.1 (.42)**
Railway Magazine, October, p. 245.
ALLEN (C. J.). — **113 m.p.h. on the « Silver Jubilee ».** (1 100 words & fig.)

1936 **656 .222.1 (.42)**
Railway Magazine, October, p. 247.
ALLEN (C. J.). — **British locomotive practice and performance.** (4 500 words & fig.)

Railway Mechanical Engineer. (Philadelphia.)

1936 **656 .221 (.73) & 621 .43 (.73)**
Railway Mechanical Engineer, September, p. 375.
Union Pacific **streamline trains.** (6 000 words & fig.)

1936 **621 .43 (.73)**
Railway Mechanical Engineer, September, p. 383.
Busch-Sulzer 2 000 h. p. switcher. (5 800 words & fig.)

1936 **621 .134.2 & 621 .134.3**
Railway Mechanical Engineer, September, p. 391.
SMITH (J. E.). — Link motion **valve gear.** (3 200 words & fig.)

1936 **625 .235 (.73)**
Railway Mechanical Engineer, September, p. 395.
Metlvane **blind for passenger cars.** (700 words & fig.)

Railway Signaling. (Chicago.)

1936 **625 .162 (.73) & 656 .259 (.73)**
Railway Signaling, September, p. 459.
North Western installs **automatic gates.** (2 800 words & fig.)

1936 **656 .258 (.73)**
Railway Signaling, September, p. 464.
Reconstruction of interlocking at the Dallas Union terminal. (3 400 words & fig.)

1936 **625 .162 (.73) & 656 .259 (.73)**
Railway Signaling, September, p. 468.
KIVLEN (J. P.). — **Highway crossing protection** on the Northampton & Bath. (900 words & fig.)

1936 **385 .3 (08 (.73) & 313 : 656 .25 (.73)**
Railway Signaling, September, p. 470.
I. C. C. issues **annual signaling statistics.** (1 000 words & 2 tables.)

1936 **656 .25 (.06 (.73)**
Railway Signaling. September, p. 471.
Brotherhood of Railroad Signalmen of America convenes in Chicago. (3 400 words.)

1936 **621 .43 (.73) & 656 .254 (.73)**
Railway Signaling, September, p. 474.
Train control on the Baltimore & Ohio diesel. (800 words & fig.)

1936 **656 .258 (.71)**
Railway Signaling, September, p. 475.
Automatic interlocking replaces mechanical plant in Canada. (1 800 words & fig.)

1936 **656 .257 (.73)**
Railway Signaling, October, p. 513.
Centralized control on the Chesapeake & Ohio. (4 000 words & fig.)

1936 **621 .39 (.73) & 656 .253 (.73)**
Railway Signaling, October, p. 519.
STILWELL (W. H.). — **Electric lighting of semaphores.** (750 words & fig.)

1936 **625 .162 (.73) & 656 .259 (.73)**
Railway Signaling, October, p. 525.
Special control circuits for **crossing protection** on Reading Company. (1500 words & fig.)

1936 **62. (01 & 691**
Railway Signaling, October, p. 529.
COLLEY (R. H.) & AMADON (C. H.). — The relation between penetration and decay in **creosoted southern pine poles.** (2 200 words, 3 tables & fig.)

South African Railways and Harbours Magazine. (Johannesburg.)

1936 **621 .43 (.68)**
South African Rys. & Harbours Magazine, September, p. 1143.
420-h.p. railcars for branch line service on the South African Railways. (1 700 words & fig.)

The Locomotive. (London.)

1936 **621 .132.3 (.71)**
The Locomotive, September 15, p. 270.
Streamlined 4-8-4 locomotives, Canadian National Railways. (1 300 words & fig.)

1936 **621 .43 (.42)**
The Locomotive, September 15, p. 272.
Vulcan-Frichs **diesel shunting locomotive.** (1 400 words & fig.)

1936 **621 .132.6 (.43)**
The Locomotive, September 15, p. 274.
New **heavy tank locomotive,** German National Railways. (1 800 words & fig.)

1936 **621 .132.3 (.51)**
The Locomotive, September 15, p. 277.
2-6-2 passenger locomotives, Pekin-Hankow Railway, China. (800 words & fig.)

1936 **621 .338 (.45)**
The Locomotive, September 15, p. 281.
Streamlined electric trains, Italian State Railways. (600 words & fig.)

1936 **621 .43 (.493)**
The Locomotive, September 15, p. 287.
820 h. p. articulated diesel-train, Belgian National Railways. (400 words & fig.)

1936 **625 .215 (.494)**
The Locomotive, September 15, p. 290.
Duplex **carriage bogie,** with free wheels. (1 000 words & fig.)

1936 **621 .132.1 (.52)**
The Locomotive, September 15, p. 292.
Recent Japanese **locomotives.** (500 words & fig.)

1936 **621 .132.8 (.55)**
The Locomotive, October, 15, p. 306.
BEYER-GARRATT **locomotive,** Iranian State Railways. (800 words & fig.)

1936 **621 .132.3 (.44)**
The Locomotive, October 15, p. 308.
« **Pacific** » **locomotive** with poppet valves, P. L. M. Railway. (1 500 words, 1 table & fig.)

1936 **385 .111 (.82) & 621 .43 (.82)**
The Locomotive, October 15, p. 311.
Diesel railcar operation on the Buenos Ayres Western Railway. (2 000 words & fig.)

1936 **621 .13 (0**
The Locomotive, October 15, p. 313.
The development and testing of locomotives. (3 900 words.)

1936 **621 .13 (0**
The Locomotive, October 15, p. 321.
Development in steam locomotive design. — Presidential address of M. W. A. Stanier to the Institution of Locomotive Engineers. (3 200 words, 1 table.)

1936 **625 .232 (.42)**
The Locomotive, October 15, p. 325.
New **buffet cars,** L. M. S. R. (1 300 words & fig.)

The Oil Engine. (London.)

1936 **385 .111 (.82) & 621 .43 (.82)**
The Oil Engine, October, p. 171.
Railcar operation in the Argentine. (1 200 words & fig.)

1936 **621 .43 & 621 .89**
The Oil Engine, October, p. 174.
BASSETT (H. N.). — **Diesel-engine lubrication.** (2 400 words.)

1936 **621 .43 (.42)**
The Oil Engine, October, p. 182.
Private shunting work around a large factory. (500 words & fig.)

Transactions, American Society of Mechanical Engineers. (New York.)

1936 **621 .13 & 662**
Transactions, A. S. M. E., August, p. 455.
BEAN (G. M.). — Equipment and problems in handling **oil as a locomotive fuel.** (5 600 words & fig.)

1936 **62. (01 & 625 .213**
Transactions, A. S. M. E., August, p. 467.
VOGT (R. F.). — **Stress and deflection of helical springs.** (4 200 words & fig.)

Transit Journal. (New York.)

1936 **388. (06 (.73)**
Transit Journal, No. 10, September 15, p. 327.
Convention-in-print of American Transit Association. A series of articles on **modernization of rapid transit equipment.**

In Bulgarian.

(= 91.881)

Spisanie. (Sofia.)

1936 **656 .254 (.43) = 91 .881**
Spisanie, No. 3, p. 70.
VASILEV. — **Telephone installations for the « train dispatching system »** at the main passenger station, Francfort/Main. (3 300 words.)

1936 **621 .43 = 91 .881**
Spisanie, No. 3, p. 89.
Railcars and their construction. (4 200 words.)

1936 **621 .43 (.437) = 91 .881**
Spisanie, Nos. 4-5, p. 129
The **railcars** of the Czechoslovak State Railways. **(Their development and construction.)** (2 100 words.)

1936 **656 .211.7 = 91 .881**
Spisanie, Nos. 4-5, p. 132.
JETIMOV. — **Ferry-boats** and their economic importance. (3 000 words.)

1936 **656 .254 (.43) = 91 .881**
Spisanie, Nos. 4-5, p. 138.
VASILEV. — **Telephone installations of the « train dispatching system »** on the Werra Railway (Germany). (2 400 words.)

1936 **313 .385 (.437) = 91 .881**
Spisanie, No. 6, p. 177.
Central statistical service, Czechoslovak Rys. (2 40[illegible] words.)

In Italian.

Annali dei lavori pubblici. (Roma.)

1936 **62.** (01

Annali dei lavori pubblici, settembre, p. 696.

SALVADORI (M.). — Le **tensioni tangenziali** nella sollecitazione di torsione, flessione e taglio. (5 000 parole.)

L'Ingegnere. (Roma.)

1936 **62.** (01 & **721** .9

L'Ingegnere, ottobre, p. 491.

COLONNETTI (G.). — Su la **resistenza alla trazione** delle strutture in beton armato. (2 700 parole & fig.)

Rivista tecnica delle ferrovie italiane. (Roma.)

1936 **656** .256.3

Rivista tecnica delle ferrovie ital., n° 3, 15 settembre, p. 133.

BAGNOLI (F.). — L'inserzione dei **segnali** a luce di colore in circuiti a corrente alternata trifase e la loro applicazione negli impianti di blocco automatici. (2 200 parole & fig.)

1936 **385** .6 & **656** .223.2

Rivista tecnica delle ferrovie ital., n° 3, 15 settembre, p. 143.

PETRORO (L.). — Nolo ed utilizzazione dei carri in servizio internazionale. (5 200 parole.)

In Dutch.

De Ingenieur. (Den Haag.)

1936 **624** .32 (.492)

De Ingenieur, nr 38, 18 September, p. B. 145.

Brugbouw Dordt en Moerdijk. (2 600 woorden & fig.)

1936 **62.** (01 & **669**

De Ingenieur, nr 38, 18 September, p. Mk. 23.

GOUGH (H. J.). — Inner characteristics of the **deformation and fracture of metals** under static and fatigue stresses, as revealed by &-rays. (800 woorden & fig.)

1936 **669**

De Ingenieur, nr 42, 16 October, p. Mk. 27.

BERGSMA (A.) & SCHOENMAKER (P.). — De **versteviging van koper.** (2 300 woorden & 3 tabellen.)

Spoor- en Tramwegen. (Utrecht.)

1936 **385.** (09 (.931

Spoor- en Tramwegen, nr 20, 29 September, p. 479.

ARTHURTON (A. W.). — De **spoorwegen in Nieuw-Zeeland.** (2 100 woorden & fig.)

1936 **621** .132.3 (.51)

Spoor- en Tramwegen, nr 21, 13 October, p. 499; nr 22, 27 October, p. 529.

JONG (J. L.). — 2 C 1-**Sneltreinlocomotieven** voor China, werkende met oververhitten stoom. (4 500 woorden & fig.)

1936 **656** .211.5 (.492)

Spoor- en Tramwegen, nr 21, 13 October, p. 503.

KOOISTRA (R.). — Het gebruik van **Automaten** door de Nederlandsche spoorwegen. (3 500 woorden & fig.)

In Czech.

(= 91.886)

Casopis pro železnični právo a politiku. (Praha.)

1936 **385** .63 = **91** .886

Casopis pro zeleznicni právo a politiku, No. 6, p. 81.

WIZDALEK. — The **international goods traffic** from the new wording of the International Convention on the transport of goods by railway (Rome edition). (6 400 words.) (To be continued.)

Železnični Revue. (Praha.)

1936 **625** .1 (.497.1) = **91** .886

Zeleznicni Revue, No. 9, p. 129.

SEJK. — The development of the Beograd-Sarajevo **narrow-gauge railway line** between Uzice and Vardiste. (The Sargan loops.) (1 400 words & fig.)

1936 **656** .211.5 = **91** .886

Zeleznicni Revue, No. 10, p. 145; No. 11, p. 163; No. 12, p. 180.

HOFFMANN. — **Station working problems** and their methodical solutions. (6 000 words.)

1936 **385** .14 (.437) = **91** .886

Zeleznicni Revue, No. 13, p. 193.

VOKOUN. — The **financial position** of the Czechoslovak State Railways, and their tariffs. (2 100 words & fig.)

Zprávy železničnich inženýrů. (Praha.)

1936 **621** .43 = **91** .886

Zpravy zeleznicnich inzenyru, No. 5, p. 69; No. 6, p. 88.

KRAL. — Power and speed characteristics of **diesel-electric railcars.** Principles on which they are based. (6 000 words & diagr.)

1936 **621** .138.2 (.437) = **91** .886

Zpravy zeleznicnich inzenyru, No. 6, p. 72.

SOUCEK. — Modern **locomotive coaling plant** (gantry crane), Ceska Trebova depot, Czechoslovakia. (2 700 words.)

1936 **656** .222.4 = **91** .886

Zpravy zeleznicnich inzenyru, No. 6, p. 74.

ZOPF. — Selecting a **graphical method for the establishment of train running times.** (4 900 words & fig.)

1936 **621 .132.3 (.438) = 91 .886**

Zpravy zeleznicnich inzenyru, No. 6, p. 85.

PROCHAZKA. — Class 387-0 **locomotive for express trains,** Czechoslovak State Railways. (5 500 words & fig.)

1936 **625 .13 (.437) = 91 .886**

Zpravy zeleznicnich inzenyru, No. 6, p. 90.

VAVRIK. — The raising of a railway bridge on the Praha-Dobris line and the relocation of railway lines near Vrane, necessitated by the construction of a dam in the Vltava valley. (4 900 words & fig.)

1936 **385 .587 (.437) = 91 .886**

Zpravy zeleznicnich inzenyru, No. 6, p. 95.

RYCHLIK. — New workshop organisation, Czechoslovak State Railways. (2 200 words.)

1936 **385 .57 = 91 .886**

Zpravy zeleznicnich inzenyru, No. 6, p. 97.

SERACKY. — Psychotechnics and the railways. (2 700 words.)

In Jugoslav.

(= 91.882)

Saobračajni Pregled. (Beograd.)

1936 **621 .138.5 = 91 .882 & 656 .26 = 91 .882**

Saobracajni pregled, No. 3, p. 65.

LAZIC. — **Internal organisation of large railway shops.** (18 900 words.)

1936 **624 .3 = 91 .882**

Saobracajni pregled, No. 4, p. 97.

BURKOVIC. — The height of lattice girders of **railway metal bridges** of 30 to 40 m. span. (17 500 words, diagr. & fig.)

1936 **621 .33 (.65) = 91 .882**

Saobracajni pregled, No. 5, p. 129.

RUZIC. — **Electric traction** on the Algerian Railways. (10 800 words, diagr. & fig.)

1936 **621 .13 = 91 .882**

Saobracajni pregled, No. 5, p. 144.

LONCAREVIC. — **Fast steam locomotives.** (7 650 words & fig.)

In Polish.

(= 91.885)

Inzynier Kolejowy. (Warszawa.)

1936 **385 .15 = 91 .885**

Inzynier Kolejowy, No. 9, p. 302

LOPUSZYNSKI (M.). — **Railway operating principles.** (6 700 words.)

1936 **621 .13 (.438) = 91 .885**

Inzynier Kolejowy, No. 9, p. 308.

PAWLOWSKI (A.). — Principles governing **locomotive construction** in Poland in relation to industrial progress. (5 500 words & fig.)

1936 **621 .43 (.438) = 91 .885**

Inzynier Kolejowy, No. 9, p. 313.

Development of motor traction on the Polish State Railways. (7 500 words & fig.)

1936 **621 .133.1 = 91 .885**

Inzynier Kolejowy, No. 9, p. 327.

FELSZ (S.). — Comparative statistics of **locomotive fuel consumption.** (4 000 words, 2 tables & fig.)

1936 **625 .172 = 91 .885**

Inzynier Kolejowy, No. 9, p. 331.

WALIGORSKI (T.). — **Weeding railway track** by the « Herbotox » chemical process. (4 400 words & fig.)

In Portuguese.

Revista das Estradas de ferro. (Rio de Janeiro.)

1936 **385. (09 (.7 + .8)**

Revista das Estradas de ferro, nº 268, 15 setembro, p. 1365.

Estradas de ferro do continente americano. (2 700 palavras.)

In Rumanian.

= 599

Revista tecnica C. F. R. (Bucuresti.)

1936 **621 .33 (.498) = 599**

Revista tecnica C. F. R., May-June, p. 136.

SERBANESCU (D.). — **Electrification** and the Rumanian Railways. (7 800 words & fig.)

1936 **625 .14 = 599**

Revista tecnica C. F. R., May-June, p. 160.

MIHAIL (P.). — **Modern calculation of railway track.** (3 000 words.)

1936 **621 .43 (.437) = 599**

Revista tecnica C. F. R., July-August, p. 205.

VASU (L.). — **Composite railcars,** Czechoslovak State Railways. (900 words & fig.)

1936 **656 .224 = 599**

Revista tecnica C. F. R., July-August, p. 210.

The International Sleeping Car Co. (16 000 words & a map.)

1936 **625 .212 = 599**

Revista tecnica C. F. R., No. 4, p. 97.

VAIDEANU. — Causes of **tyre breakages.** (20 400 words, diagr. & fig.)

1936 **625 .2 = 599 & 669 = 599**

Revista tecnica C. F. R., No. 4, p. 118.

TRAUSAN. — **Special steels** used in the construction of rolling stock. (8 800 words.)

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OL. XVIII — N° 12 DÉCEMBER 1936

Monthly Bulletin of the International Railway Congress Association

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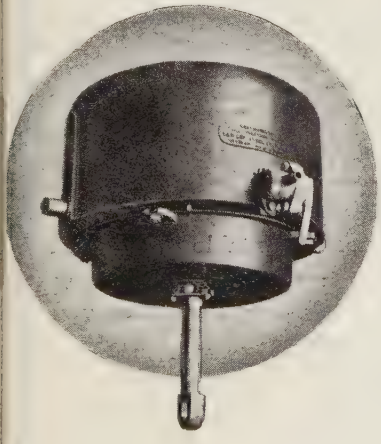

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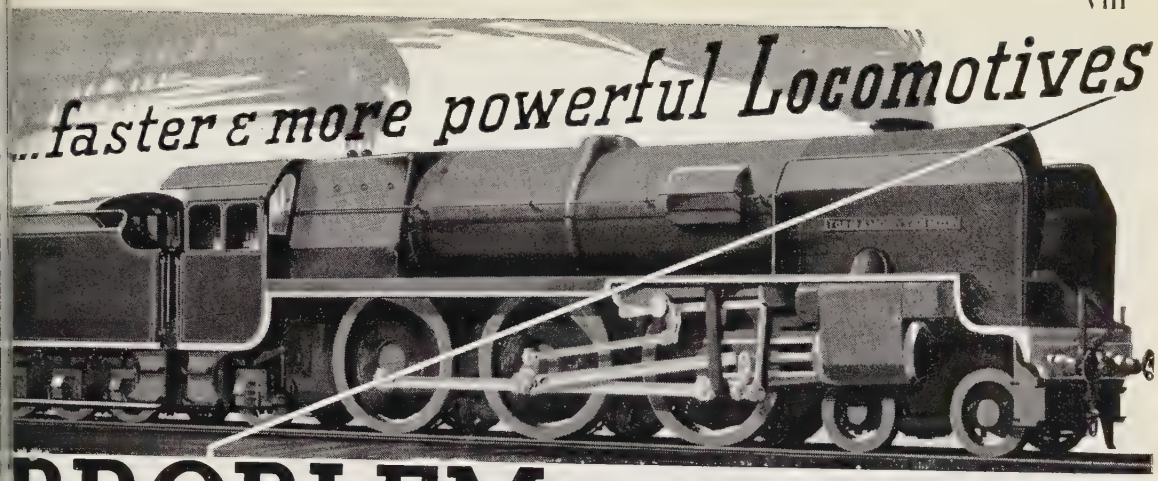

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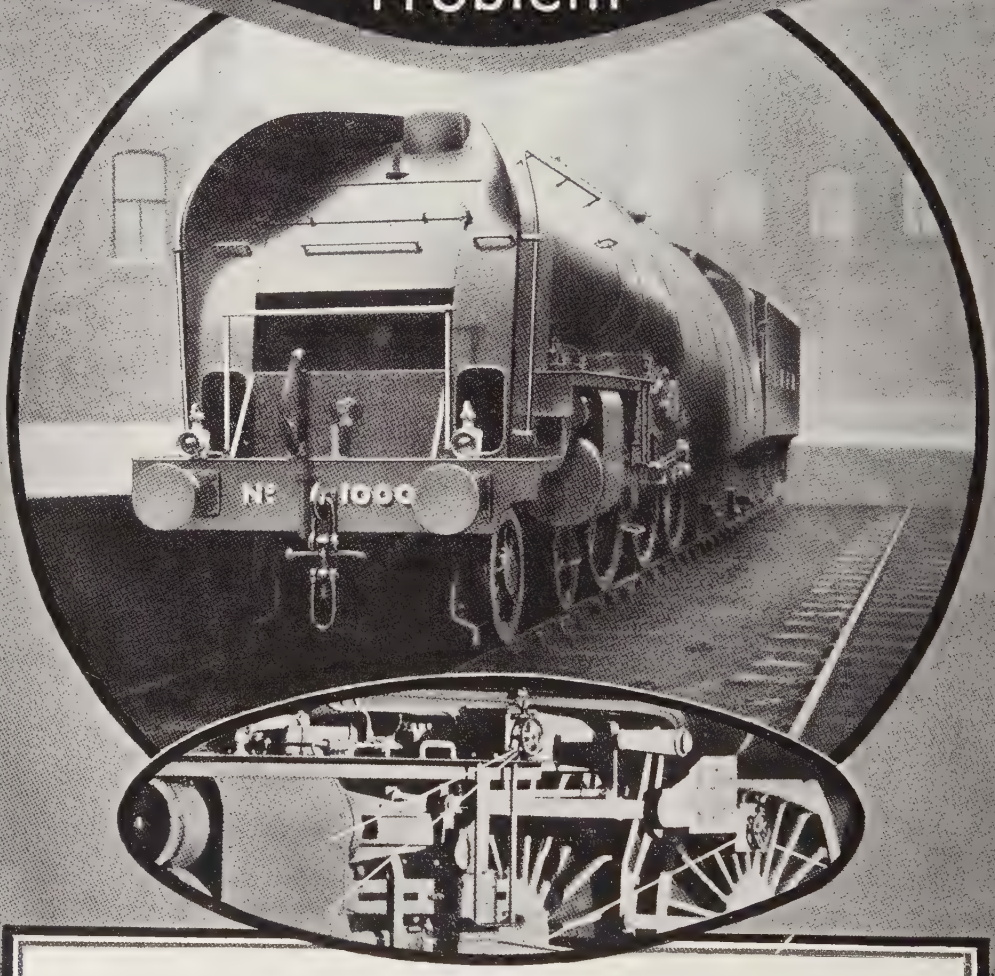

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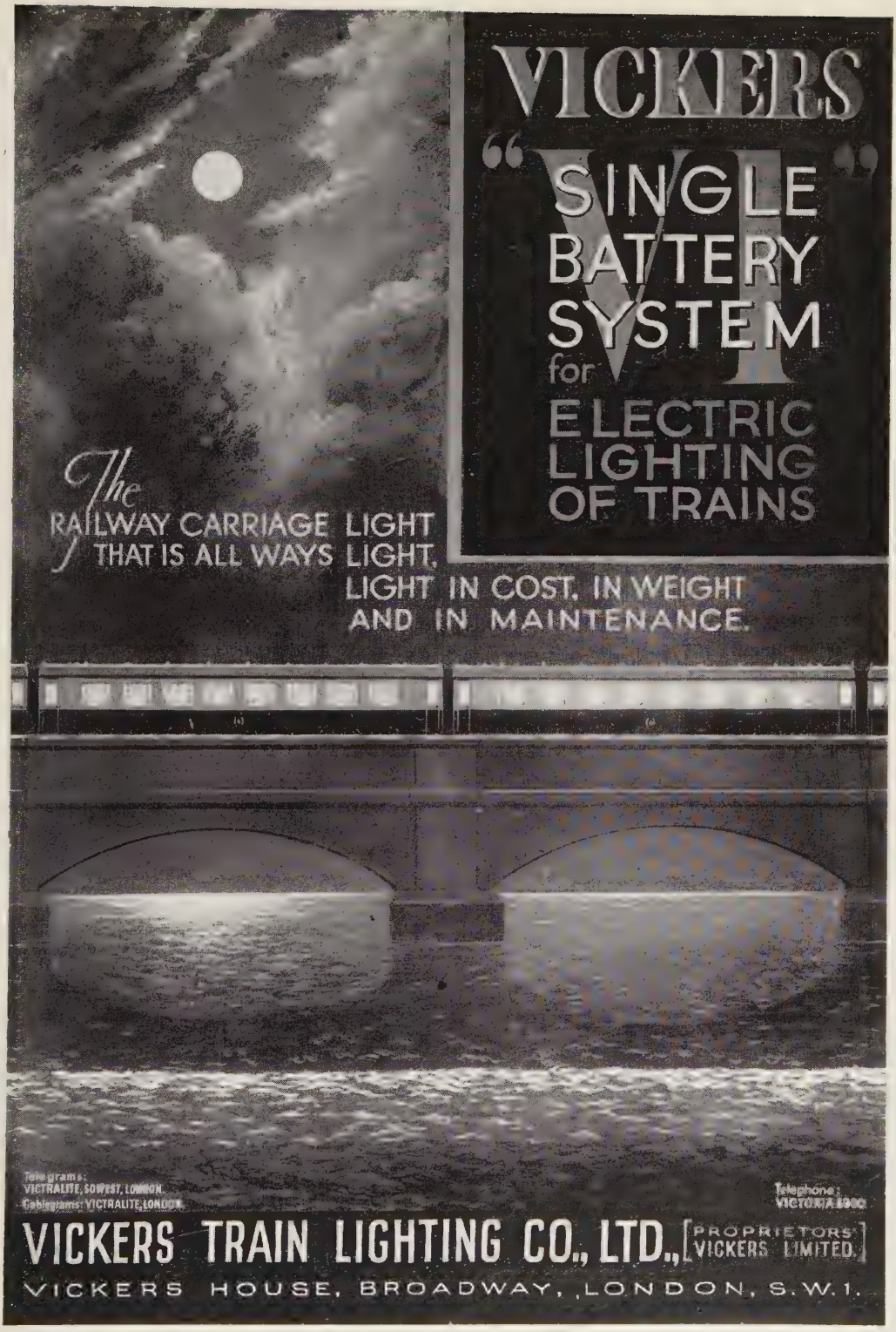
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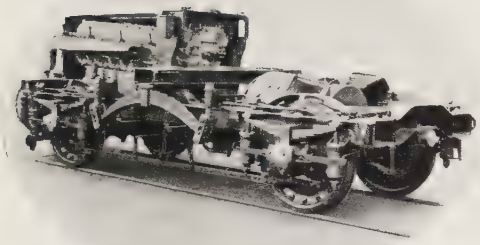

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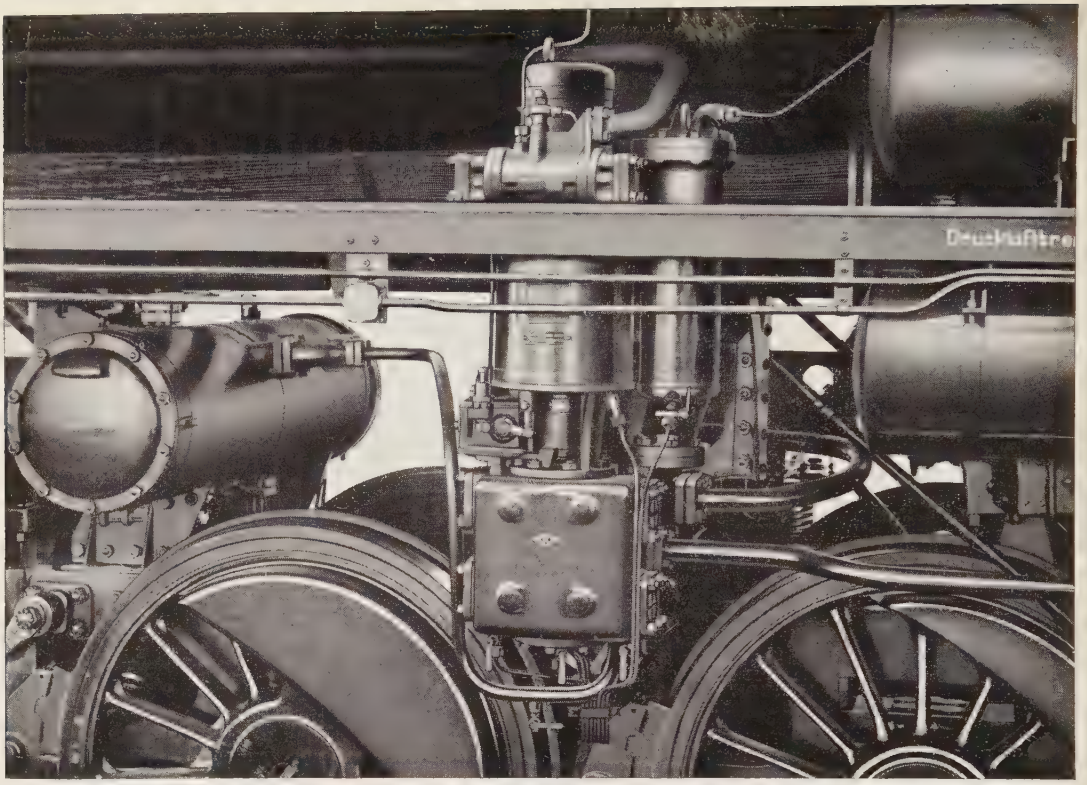

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CONTENTS OF THE NUMBER FOR DECEMBER 1936.

1936 **621 .13**

Bull. of the Int. Ry. Congress Ass^on, No. 12, Dec., p. 1291.

GRESLEY (Sir H. Nigel). — **Recent improvements in steam locomotives of the usual type and tests of new designs (high pressure reciprocating locomotives and turbine locomotives)** as regards construction, quality of materials used, efficiency, working conditions, maintenance and financial results. — **Testing locomotives at experimental stations, and in service with dynamometer cars and brake locomotives** (Subject V, 13th Congress). — Report (*Great Britain, Dominions and Colonies, America, China and Japan*). (40 500 words, tables & fig.)

1936 **625 .14**

Bull. of the Int. Ry. Congress Ass^on, No. 12, Dec., p. 1447.

FLAMENT (H.). — **The construction of modern track to carry heavy loads at high speeds and methods of modernising old track for such loads and speeds. Facing points that can be taken at high speeds** (Subject I, 13th Congress). — Report (*France and Colonies, Spain, Portugal and Colonies, Italy, Czechoslovakia, Bulgaria, Rumania, Jugoslavia, Greece, Turkey, Egypt*) (24 700 words, tables & fig.)

1936 **385 .57**

Bull. of the Int. Ry. Congress Ass^on, No. 12, Dec., p. 1549.

LO BALBO (P.). — **Selection, orientation and instruction of railway staff** (Subject XI, 13th Congress). Report (*Italy, Spain, Portugal and Colonies, Great Britain, Dominions and Colonies, America, China, Japan, Egypt*). (4 500 words & fig.)

1936 **385 .57**

Bull. of the Int. Ry. Congress Ass^on, No. 12, Dec., p. 1569.

WOJCIECHOWSKI (J.). — **Selection, orientation and instruction of railway staff** (Subject XI, 13th Congress). Report (*Poland, Germany, Netherlands and Colonies, Denmark, Norway, Sweden, Finland*). (4 200 words, table & fig.)

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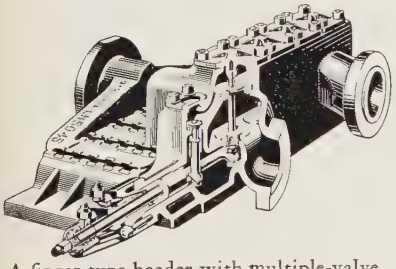

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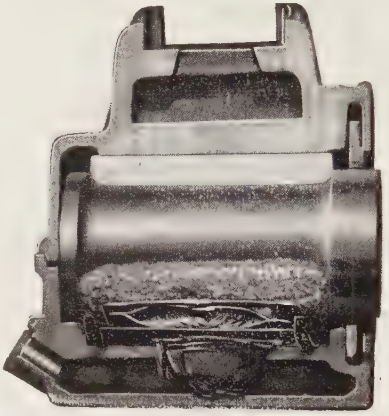

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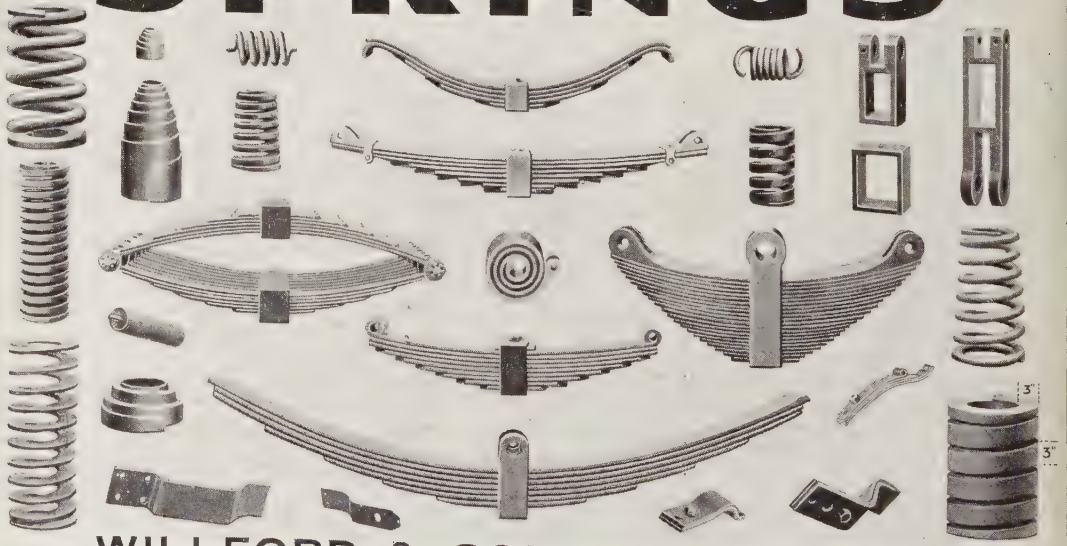

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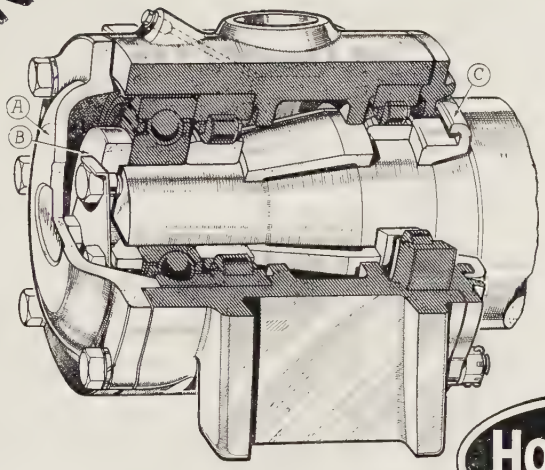

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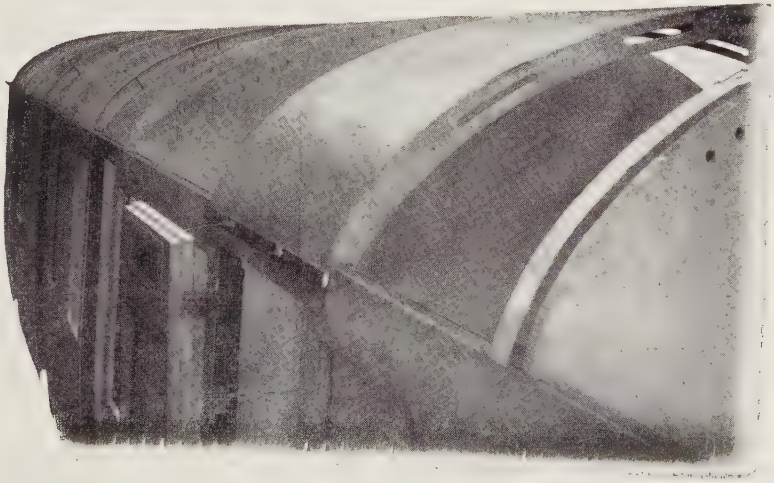

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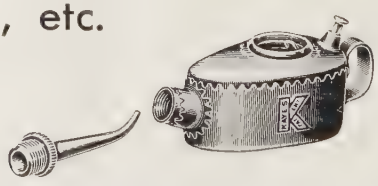

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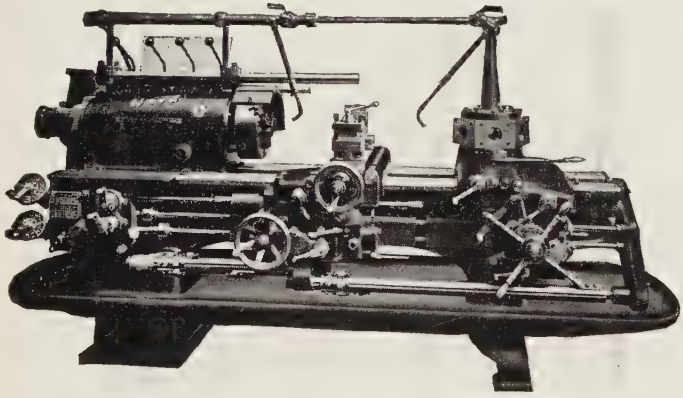

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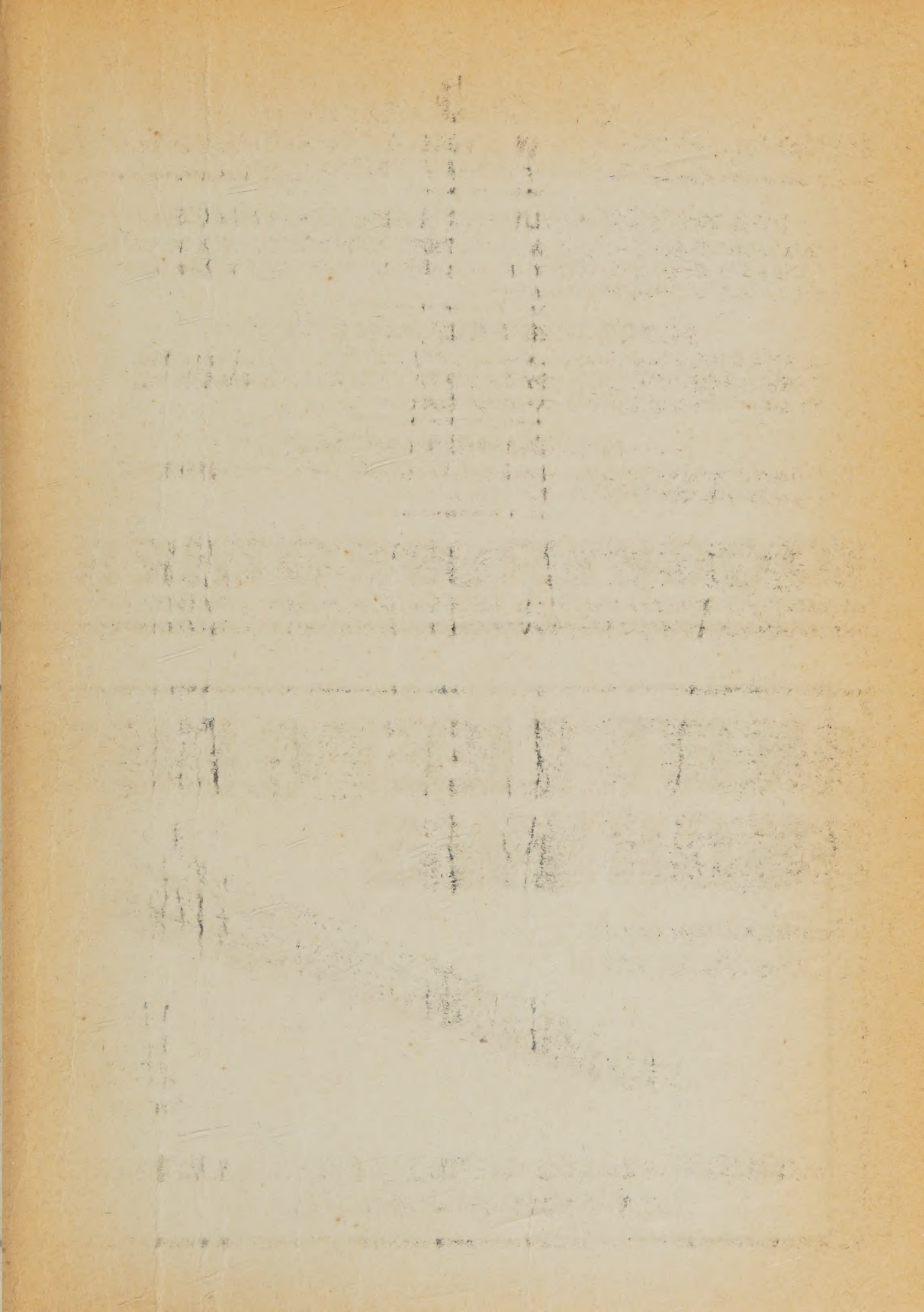

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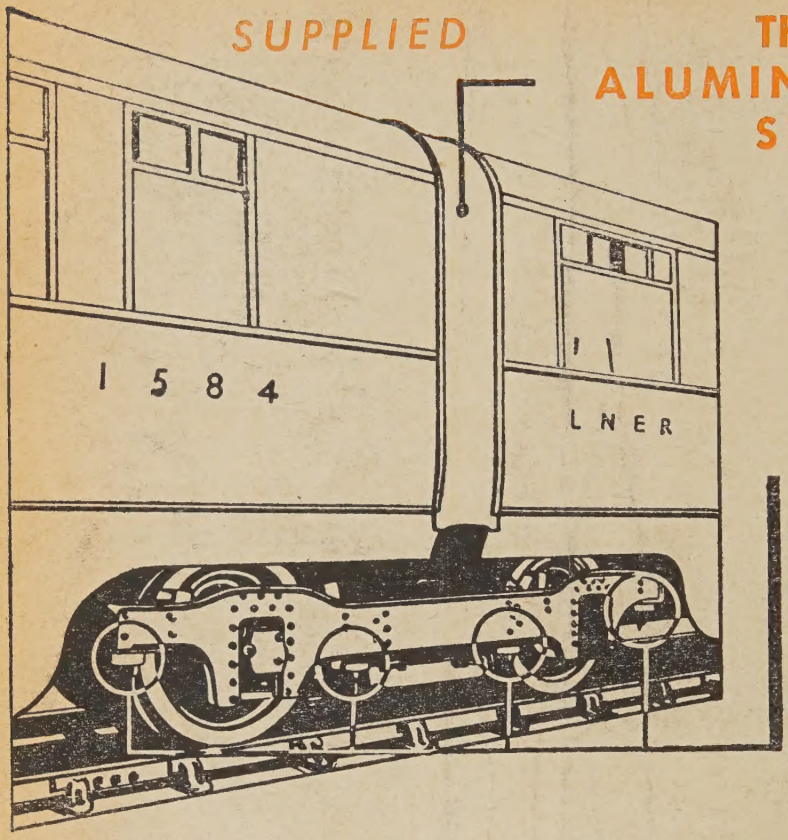

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